REPORT OF THE

NATIONAL COMMISSION ON AGRICULTURE

PART V

RESOURCE DEVELOPMENT

GOVERNMENT OF INDIA
MINISTRY OF AGRICULTURE AND IRRIGATION
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PREFACE

The Report of the National Commission on Agriculture comprises 69 chapters in 15 parts. A complete list of chapters and parts is given in pages (iii), (iv) and (v). The Terms of Reference of the Commission and its composition are given in Part I—Chapter I—Introduction.

This volume, entitled 'Resource Development' is Part V of the Report and is divided into the following five chapters :

15. Irrigation
16. Command Area Development
17. Land Reclamation and Development
18. Soil and Moisture Conservation
19. Electricity in Rural Development

Improvement of irrigation statistics has been discussed in Chapter 61 on Statistics in Part XIV.

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NATIONAL COMMISSION ON AGRICULTURE

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PART V

RESOURCE DEVELOPMENT

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CHAPTER 15—IRRIGATION

15

IRRIGATION

1 INTRODUCTION

15.1.1 Water is the most important single requirement for the growth of plant. Crops can be raised successfully only if water is available in adequate quantity either from rain or surface flow or below ground. Rainfall in most parts of the country is confined mainly to the four rainy months of June to September. During the remaining months the water requirements have to be met from ground or surface water resources. The need of applying irrigation for raising crops during non-rainy periods or when rains failed was felt even in the distant past. Artificial irrigation was practised in India as far back as the fourth millennium B. C. With the growth of population and consequent need for larger agricultural production, the requirement of irrigation has increased a great deal. Irrigation is required not only in low rainfall areas and during non-rainy season but also during long breaks in rains in good rainfall areas. Modern research has highlighted the importance of adequate soil moisture during the crucial stages of plant growth and in consequence of adequate irrigation facilities.

15.1.2 In olden days, water resources were generally plentiful in relation to man's needs. Irrigation was done in a manner that did not take note of its possible long range ill effects as these were hardly understood. Several civilisations came to grief through the ill effects of unscientific use of irrigation supplies or failure of irrigation works through the slow process of geomorphological change. For example, for want of proper drainage, irrigation led to high water table which in turn made the soil saline and infertile in some areas. Some diversion works failed because of the deepening of river channels due to erosion. Sediment filled up some tanks and rendered them useless. But science and technology have made great progress in recent years in remedying some of the ill effects and these have to be fully brought to bear on present day irrigation.

15.1.3 We have attempted to size up the water resources that can be ultimately harnessed for irrigation. We have also figured out the land that is expected to be available for cultivation in the next

50 years as also the cropped area. It has been estimated that out of the 400 million hectare metres (Mham) of average annual precipitation that takes place in India, only about 105 Mham can be ultimately harnessed for various uses besides about 125 Mham that would get utilised directly for transpiration. The rest would evaporate or flow out of the country or into the sea. The present utilisation is 38 Mham through water resource development and about 110 Mham directly through transpiration. As regards land resources, of the geographical area of 328 million hectares (Mha), in 1970-71, 140 Mha was under cultivation with a total of 165 Mha under crops. Through various changes in land use over the next 50 years, the cultivated area may increase to 155 Mha and the cropped area to 210 Mha. It should be possible to irrigate about 110 Mha of the cropped area on full development of irrigation. At present only about 42 Mha is being irrigated.

15.1.4 To achieve the ultimate goal of irrigation and to derive the maximum benefit from the existing irrigation facilities, several steps have to be taken. In brief, water resources have to be harnessed, managed and utilised more economically and efficiently, and financial policies reoriented to meet the situation. The policies and considerations concerning irrigation were dealt with recently by the Irrigation Commission, which the Union Government had set up in 1969, and are contained in its report of 1972. In the succeeding sections of this chapter, we have underscored some of the recommendations as deserving of special notice and have added some more which we consider important enough from the point of view of proper development of water resources and better use of irrigation facilities.

15.1.5 We submitted in February 1973, an Interim Report on modernisation of the old and earlier plan projects and integrated development of commanded areas[1]. We had felt that action on these important matters should be taken without loss of time and reasonable funds provided for the purpose in the Fifth Plan which was under formulation at the time. We have briefly touched upon some of those matters in the present chapter again.

2 WATER RESOURCES

Hydrological Cycle in India

15.2.1 The summer monsoon starting from the equatorial belt comes over the Indian subcontinent in two distinct currents known

1 Interim Report on Modernising Irrigation Systems and Integrated Development of Commanded Areas; hereafter referred to as Interim Report on Modernising Irrigation Systems.

as the Bay of Bengal branch and the Arabian Sea branch. It has been estimated that during the four rainy months of June to September the Arabian Sea branch of the monsoon carries moisture amounting to about 770 Mham and the Bay of Bengal branch about 340 Mham of water. Of the monsoon moisture about 25 to 30 per cent precipitates in the form of rainfall. During the remaining eight months of the year also, there is a substantial amount of moisture over the country. This, however, has not as yet been scientifically assessed. It contributes a precipitation of the order of 100 Mham, a small part of it being in the form of snowfall. Rainfall in the country varies from place to place but the annual average for its total area of 328 Mha is about 120 cm. The average annual precipitation is thus of the order of 400 Mham.

15.2.2 When rain falls, a portion of it soon evaporates from the ground or the vegetation that may intercept it, a portion soaks into the ground and the rest flows away over land as runoff. When rainfall is very light, say of the order of 2.5 mm or less, it only moistens a few millimetres of top soil with nothing percolating down or flowing over ground. The whole of it then rapidly evaporates from the surface.

15.2.3 Of the portion of precipitation that soaks into ground a good deal is retained in the soil as soil moisture. Whatever is in excess of the water-holding capacity of the soil infiltrates as groundwater to the groundwater reservoir. A major portion of the soil moisture is used by plants for transpiration and a small portion is drawn to the surface by capillary action and evaporates. Nature also stores some water in the form of snow on mountains which on melting feeds the streams that originate there. The snowfields thus act as reservoirs in the same way as the groundwater storage by holding back water received from precipitation and releasing it gradually later.

15.2.4 Besides the contribution to groundwater from rainfall, there is a substantial contribution from irrigation systems, particularly in areas with large scale irrigation. In the alluvial plains of north India, about 45 per cent of the water that is let in at the head of an unlined canal system is lost through seepage. Of the remaining 55 per cent which reaches the field, another 17 per cent is lost from the field itself. Thus only about two-fifths of the water is utilised there. In heavier soils, or where the channels are lined, the loss is less. The water which seeps from most unlined channels, particularly in the alluvial soil partly goes to moisten the adjoining land and partly percolates down to groundwater table. Moisture from this moistened land is dissipated through evaporation and transpiration. In addition to the groundwater recharge from rainfall and irrigation systems, there is a significant contribution from infiltration from rivers and streams during their high stages of flow.

15.2.5 The water that infiltrates from rainfall, irrigation systems, rivers, streams and drains raises the groundwater table. There it does not remain static but moves through the soil laterally. A portion of it is extracted through wells, tubewells, etc. for irrigation and other uses. A small amount also evaporates through capillary action where watertable is high. The rest flows back to the surface at lower elevation in the form of springs, seepage, and regenerated flows in rivers and streams. The process is slow and gradual. If the annual contribution to groundwater reservoir is in excess ot what is utilised or disposed of in the above manner, the groundwater table rises, and if it is less, the table drops. Over a period the inflow and outflow tend to attain equilibrium.

15.2.6 As regards surface water, the total surface flows consist of direct runoff from precipitation, snowmelt and regenerated flows in streams. The surface water is disposed of in three ways. Part of it is stored in reservoirs or is utilised directly by diversion or pumping, part disappears as percolation from streams when groundwater table is below the stream surface and the rest finds its way to the sea. A portion of the water stored in reservoirs is lost through evaporation and a small amount through leakage; the rest is utilised for various purposes, mainly irrigation. With the intervention in the natural water cycle by man, like the construction of more projects, there would be a quantitative change in the various steps through which surface water passes. More would be utilised for irrigation and other purposes and there would be less flowing down to the sea. For keeping the rivers in proper state of conservancy a certain flow in them is necessary.

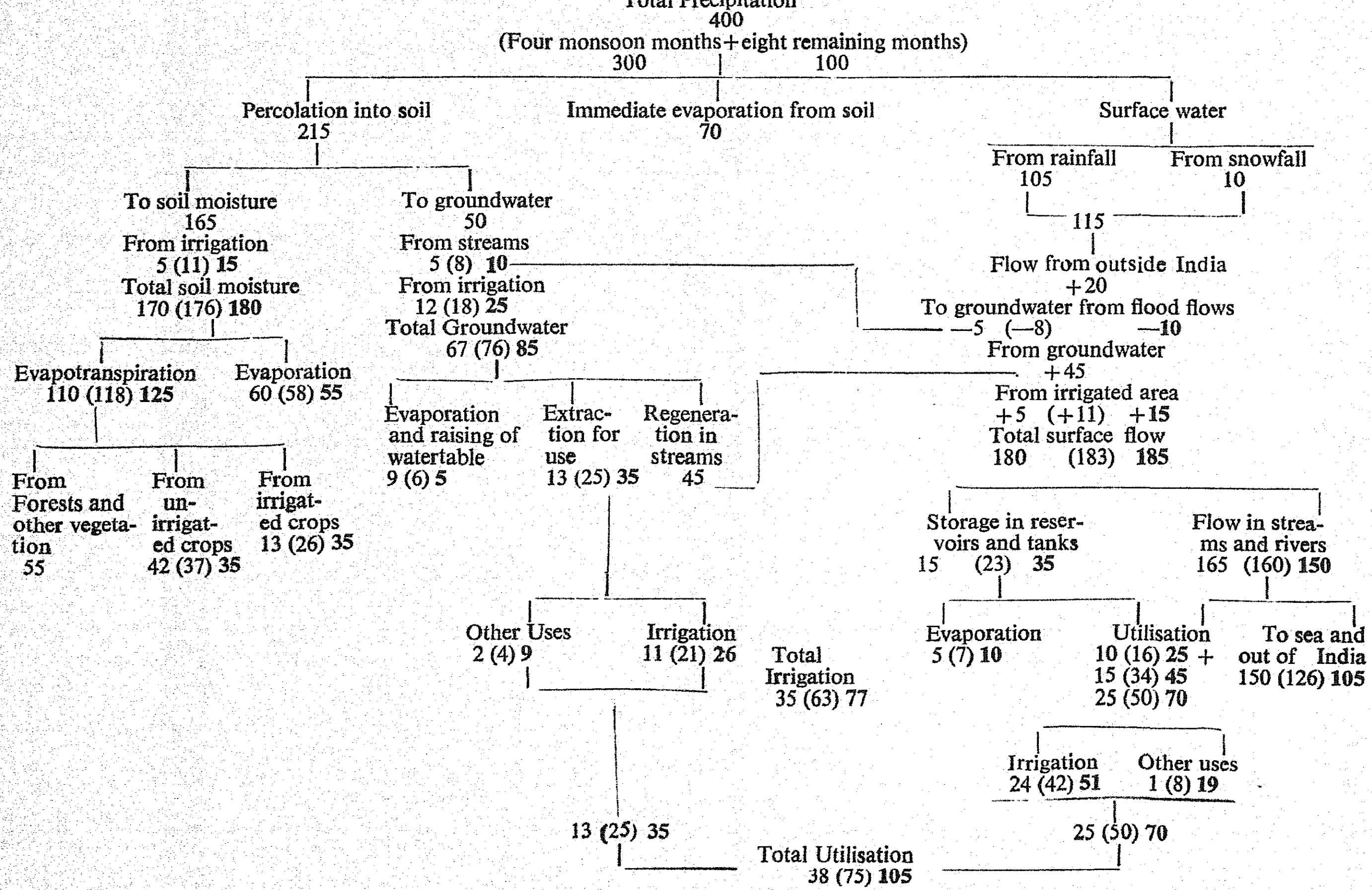
15.2.7 The annual replenishable water resources of the country are what the yearly precipitation yields, augmented by flows of rivers and streams with their source beyond the border. From this has to be taken out flows which have to be passed on to neighbouring countries. The average annual precipitation in the country is about 400 Mham. Its subsequent deployment through various processes, as at present and in 2000 A.D. and that as might emerge about 50 years from now which it may take to develop the water resources fully, is shown in the chart on the next page. In the absence of comprehensive observations and data compilation the figures in the chart represent only broad magnitudes and should be treated merely as indicative and not definitive. An explanatory note on the chart is at Appendix 15.1.

Total Water Resources

15.2.8 Estimates of the country's water resources have been made from time to time. At the beginning of the present century, the first Irrigation Commission (1901—03) had placed the surface water

Approximate Distribution of Average Annual Water Resources of India as in 1974, (2000 A.D.) & 2025 A.D.

(million hectare metre)



resource at 144 million hectare metres for India of that time but excluding Burma, Assam and East Bengal. In the absence of adequate data for this assessment, that Commission had described this estimate as "mere approximation". In the late forties, A. N. Khosla, then Chairman of the Central Waterways, Irrigation and Navigation Commission, figured out, on the basis of an empirical formula which he had evolved, the total annual surface and groundwater resources to be 167 Mham. In the basinwise assessment contained in Volume III of the Report of the Irrigation Commission (1972), the surface water resources of various river basins aggregate to 180 Mham.

15.2.9 As would be seen from the chart which is based on estimates now made in the Commission the basic surface water resources derived from precipitation amount to 115 Mham. To these are added 20 Mham brought in from catchments lying outside the country. As regards groundwater, the portion of the precipitation that goes into the soil is of the order of 215 Mham. A portion of it, roughly estimated at 165 Mham is held as soil moisture and the remaining 50 Mham percolates to watertable. The soil moisture is exceedingly important for sustaining vegetation. But it cannot be extracted for purposes of irrigation or other uses. Thus, the water that percolates to the watertable may be regarded as the basic groundwater resource. The total annual basic water resources of the country are thus 185 Mham comprising 135 Mham of surface water resources and 50 Mham of groundwater resources. But as is evident from the chart, there is interchange at various stages between the surface water and groundwater besides some recirculation. Both get augmented as a portion of surface water on use or otherwise goes to groundwater and a substantial portion of groundwater reappears as surface water. The present total groundwater is thus of the order of 67 Mham of which 45 Mham regenerates during the non-monsoon period as surface water bringing the surface water total to 180 Mham. On full development of water resources, the total groundwater would increase to 85 Mham and the surface water to 185 Mham including 45 Mham regenerated from groundwater. As explained later, not all of that is utilisable.

15.2.10 Besides the renewable water resources, there are water resources which have accumulated above and below ground over long periods. Above the ground these are glaciers and permanent snow-caps on high mountains, which make some steady contribution to the flows of the Himalayan rivers. There is trapped groundwater in certain geological formations. These trapped waters when mined are not replaced and are, therefore, an exhaustible asset. But locally these are of immense value, particularly in arid regions such as west Rajasthan. As groundwater explorations proceed, more fossil water in arid regions is likely to be discovered. Along the coast, sea water

can be a source of fresh water on desalination. Desalinated water is, however, expensive and therefore its use can be contemplated mainly for domestic and industrial purposes. With the present technology, it would be generally too expensive for irrigation. The total water resources of the country thus comprise the annually replenishable surface water and groundwater resources indicated earlier, the fossil water under ground which is an exhaustible asset, glaciers and permanent snows which make some steady contribution to river flows and the expensive desalinated water which can be produced on the coast.

15.2.11 Of the moisture which appears over India during a year only about 25 to 30 per cent precipitates there. It should be possible, by inducing artificial rainfall, to take some more water from this moisture. More than 50 countries have been conducting experiments in rain-making by cloud seeding. In India, such experiments have been carried out, in a modest way, since 1952. The process of artificial rain-making consists in injecting into a cumulus cloud the nuclei of a substance like silver iodide, sodium chloride, dry ice (solid carbon dioxide), etc. There is good evidence that clouds with temperature ranging between $-5°$ and $-20°C$ are almost always deficient in nuclei. At lower temperatures *in situ* nuclei become adequate to promote rainfall. For successful operation, the cloud has to be more than a thousand metres in depth. Notwithstanding the tall claims of success made in certain countries, the limitations in artificial rain-making have to be recognised. It is only clouds of a suitable type, viz., cumulus and of an adequate size, which can be successfully seeded. These cannot be made to appear whenever and wherever one wants them. Till further advance is made in the technique of artificial rain-making to ensure dependable results, it would be premature to take this source into account in an assessment of water resources of an area.

Utilisable Water Resources

15.2.12 Because of concentration of rain in most parts of the country during a few months of the year, maximum river flows occur during that period. During the non-rainy months the river flows dwindle to a fraction of their flood flows and some streams dry up altogether. As rainy season flows cannot be fully utilised during that short period, the waters have to be stored in reservoirs for regulated release for subsequent use. Large storage reservoirs can only be built in the hills but suitable sites for dams are limited and in consequence on some major rivers enough storage capacity is not available for completely harnessing the river flows. Also, most irrigation projects in the country are designed for a dependability of 75 per cent, which means that in 25 years in a hundred there is shortage of water and

in 75 years there is some excess over the quantity planned for utilisation on the project. Some flood flows, therefore, have to continue to go to the sea. This is not altogether a waste of water resource, as these flood flows help in river conservancy by flushing the waterways, keeping the river mouths open for navigation and preventing sea water intrusion further upstream. The Brahmaputra valley in Assam is quite narrow having a mean width of only about 90 kilometres. For the enormous size of the river, there is not enough land to utilise its water. Most of its water, therefore, has to flow down to Bangladesh and on to the Bay of Bengal. Similarly, because of their short length to the sea and the consequent constraint of paucity of land, the west flowing rivers south of the Tapi do not offer much scope for utilising their waters.

15.2.13 The average annual flows of the various rivers or groups of rivers and the amounts at present considered utilisable excluding evaporation losses from reservoirs and streams are shown below :

(million hectare metres)

	Average annual flow	Utilisable flow	Approximate present utilisation (1974)
Indus Basin	7.7	4.6	3.7
Ganga Basin	51.0	25.0	8.5
Brahmaputra Basin (including Barak) . .	54.0	2.4	0.5
Mahanadi and other east flowing rivers up to Godavari	12.3	9.1	2.8
Godavari, Krishna and other east flowing southern rivers	22.5	19.0	7.3
west flowing rivers south of Tapi	21.8	3.0	1.1
Narmada and Tapi	6.2	4.9	0.6
west flowing rivers north of Narmada . . .	2.5	2.0	0.5
total	178.0 or 180.0	70.0	25.0

Of the utilisable surface waters, the Ganga basin has the maximum potential followed by the Godavari and the Krishna. The Mahanadi is another river which has considerable water available for use. For ensuring the utilisation indicated above, a number of additional measures would be necessary. On rivers with large unutilised flows, like the Ganga, more water should be used by diverting flood flow for irrigating crops during *kharif* season which would also increase groundwater recharge. Also, greater recharge of aquifers can be secured along

rivers and streams by depressing the premonsoon groundwater table there through larger exploitation of groundwater. Wherever feasible, surplus waters in a river, such as in the Brahmaputra, the Ganga, and the west flowing rivers south of the Tapi, should be utilised in other basins where there is paucity of water. This, however, would in most cases involve considerable pumping and would be somewhat expensive. All these possibilities need to be examined and considered.

15.2.14 As regards groundwater, the utilisable amount depends not only on the quantity of water available in an area but also its quality. Excluding exploitation of fossil water, the upper limit for exploiting groundwater would be the annual recharge including induced recharge reduced by whatever is lost by evapotranspiration and subsurface runoff or is otherwise unutilisable. On expansion of irrigation with new projects there would be more recharge due to seepage from canals and in spite of emphasis on lining irrigation channels, there would be a net increase in infiltration. In arid areas, groundwater is very valuable. In most situations, however, it is saline and in places unusable. With the new knowledge of plant physiology, soil science and modern irrigation techniques, it is possible to grow some selected crops with moderately saline water and secure reasonable yields. Where good surface water is available in arid areas either locally or by transfer from another basin, it can be utilised for diluting saline groundwater for irrigating a larger area.

15.2.15 The available water resources in an area can be made to confer increased benefit through reuse and recycling of water. For example, water received in a drain from an irrigation system can be used for irrigation in areas lower down or pumped back into the canal for reuse if suitable in quality. This is already being practised in certain rice areas in Kashmir valley and can possibly be adopted in flat rice areas elsewhere, say, in Kerala and Orissa. Using treated municipal waste water is especially attractive for irrigating certain crops on lands close to cities as the plant nutrients in the sewage water ensure good yields. Recycling and reuse of water in industries, with proper treatment, can also extend usable water resources. Altogether the utilisable surface flows aggregate to about 70 Mham and groundwater about 35 Mham. Not all this water would be available for irrigation as there would be demands for other purposes like municipal, industrial including thermal and nuclear power etc.

Water Resources for Irrigation

15.2.16 The quantity of water utilised in 1973-74 is of the order of 38 Mham of which about 35 Mham has been for agricultural use. Although the percentage of utilisation for purposes other than irrigation

is low at present, this is expected to rise appreciably in the future with increase in industrialisation and power generation through thermal and nuclear plants. Part of these requirements will have to be met with seawater by locating some of the industries and power plants requiring large amounts of cooling water on the sea coast. Also some requirement of fresh water in the coastal areas may be met by desalination of seawater. By 2025 A.D. the requirements of fresh water for non-irrigation uses may amount to about 27 per cent of the available fresh water. These demands would increase further beyond that period. It would be reasonable to expect that about 77 Mham of water would be available for irrigation out of a total of 105 Mham available for all purposes in 2025 A.D.

15.2.17 Irrigation as at present practised in the country is somewhat extravagant in the use of water. It takes on an average 0.65 hectare metre of groundwater to irrigate a cropped hectare, and 0.90 hectare metre if the source is surface water as conveyance losses are higher. The two together give an average of 0.8 hectare metre per cropped hectare. On this basis, the available water resources would suffice for irrigating about 96 million hectares. On many canals, however, the supply of water is inadequate and crops do not receive the required amount of irrigation. Wherever possible, water resources have first to be deployed to remove this deficiency. At the same time, on many irrigation systems the present mode of utilisation of water is wasteful. On unlined canals in the alluvial tracts, only about two-fifths of water released at the canal head is utilised by crops; the rest is lost in transit and in the field. Not all these losses can be eliminated, but obviously there is scope for saving water. For this, lining of channels, proper levelling of fields and the adoption of the most suitable mode of application of water to crops are important steps. The area which can be irrigated with a given quantity of water also depends on the cropping pattern. It is envisaged that with more scientific and economical use of water in the future, the average water depth for irrigating cropped area will improve to about 0.70 metre. Taking the various factors into account, the ultimate irrigation potential, for purposes of a broad assessment, may be taken to be around 110 million hectares. This would be about 52 per cent of the sown area of 210 million hectares expected in the early part of the next century as indicated in the next section. In view of the inadequacy of water resources to meet the requirements, there is need for a great deal of efficiency and economy in water use. It may be noted that the ultimate irrigation potential of 110 million hectares now estimated is substantially more than the 81 million hectares indicated by the Irrigation Commission. That Commission had assumed a water depth for irrigation of 0.76 metre based on existing cropping pattern against 0.70 metre which we

consider can be attained with the cropping pattern suggested by us. Also, the estimate of utilisable water resources now made is higher than that indicated by the Irrigation Commission.

3 LAND RESOURCES FOR IRRIGATION

15.3.1 Water and land are amongst the most important natural resources of the country. The two together are basic to agriculture which is the major occupation of the people. Any appraisal of water resources for agriculture would, therefore, be incomplete without any examination of the quality, extent and availability of land to which irrigation can be applied for the maximum benefit. We briefly deal with it here to the extent it is relevant to the use of water resources.

15.3.2 The geographical area of the country is 328 Mha. The reporting area for which the land use statistics are available is, however, only 305 Mha. In the reporting area, in the year 1970-71, the net sown area was 140 Mha and the total cropped area 165 Mha. The gross irrigated area that year was 38.5 Mha.

15.3.3 With passage of time, as development takes place in the various sectors of the economy there will be a shift in pattern of land use. However, bulk of the land will continue to be used for raising crops and in fact some more will be brought under it. In the past, a good deal of forest area was deforested and made arable. The present forest area which according to land use statistics is 66 Mha is only 22 per cent of the reporting area and is below that recommended in the National Forest Policy. No increase in arable area is, therefore, envisaged by any reduction in the forest area. With the growth of population and industrial development, increasingly large amount of arable area will be occupied by habitations, industries, roads and railways, etc. This loss of arable area could possibly be made good partly by reclaiming culturable waste and partly by reducing the amount of fallow land. It would also be possible to bring under cultivation some desert areas by providing irrigation facilities there as is being done in Rajasthan with Rajasthan Canal. With the construction of large reservoirs, river waterways would in general shrink and some land on river banks would become available for cultivation as has happened on the Sutlej after the construction of Bhakra dam. With all the changes in the pattern of land use that are envisaged, the net sown area is expected to rise from 140 Mha in 1970-71 to only 150 Mha in 2000 A.D. and 155 Mha in 2025 A.D. The classification of area for the year 1970-71 and that anticipated in the years 2000 A.D. and 2025 A.D., the years considered for water resource development, are given in Table 15.1 for ready reference.

TABLE 15.1

Classification of Area

(million hectares)

	1970-71	2000	2025
geographical area	328	328	328
reporting area	305	318	318
forests	66	70	70
area under non-agricultural use . . .	16	26	36
barren and unculturable land (mountains, deserts and areas which can be brought under culturable use at high cost)	29	30	24
permanent pastures and other grazing lands .	13	15	15
miscellaneous trees, crops and groves not included in net sown area (thatching grass, casurina trees, bamboo bushes and other groves and trees for fuel etc.)	5	5	6
culturable waste (not cultivated at present for the last 5 years or more)	16	9	4
fallow lands other than current fallows (out of cultivation for 1 to 5 years)	9	5	3
current fallows (not cultivated within one year for some reason)	11	8	5
net area sown	140	150	155
total cropped area	165	200	210

15.3.4 There is already some multiple cropping in unirrigated area. This is expected to increase, though only to a small extent, due to soil moisture conservation measures and advancement in crop technology. The major increase in multiple cropping, however, will be in irrigated areas. But because of the total usable water resources being limited, the overall extent of multiple cropping will also be limited, although in pockets of abundant water its percentage may be quite high. The intensity of cropping in irrigated areas would vary from State to State and for the country as a whole may increase from the present 123 per cent to 142 per cent. Statewise details are given in Appendices 15.2 and 15.3. The intensity of cropping for irrigated and unirrigated area together is expected to increase from the present 118 per cent to 136 per cent. On this basis, the total cropped area in the year 2025 A.D. is likely to be 210 Mha.

15.3.5 The only areas where land would be a constraint in the development of irrigation are the Brahmaputra valley, and the coastal areas along the Western Ghats. Elsewhere there is sufficient land to make full use of water that can be harnessed.

4 PAST DEVELOPMENT OF IRRIGATION

15.4.1 At the beginning of the 19th century, irrigation works included innumerable wells all over the country, a large number of tanks in South India and several inundation canals in North India. Some of these tanks and canals were constructed centuries back. Between 1836 and 1866, four large irrigation works were constructed in the country namely the Upper Ganga canal, the Upper Bari Doab canal and the Krishna and Godavari delta systems. These proved very remunerative. In those days irrigation works were treated as commercial undertakings. But the great famine of 1876—78 gave the country a severe jolt. The First Famine Commission of 1880, set up in the wake of this catastrophe, emphasised the need for direct State initiative in the development of irrigation, particularly in the vulnerable areas. That year, a new category of unproductive works was introduced as a famine relief measure. No comprehensive plan of irrigation was, however, formulated presumably because of the complacency engendered by the comparatively good agricultural years from 1880 to 1895.

15.4.2 It was again the tragedy of famines in 1897-98 and 1899-1900 that led to the setting up of the first Irrigation Commission in 1901 to ascertain the utility of irrigation as a means of protection against famine, the extent of irrigation development and the scope for further irrigation works. About this time the gross area irrigated from public works in British India was about 7.5 Mha of which 3 Mha was from minor works like tanks, inundation canals etc., for which no separate capital accounts were maintained. The area irrigated by protective works was only a little over 0.12 Mha. Private works irrigated 5.7 Mha, about 70 per cent by wells and the remaining from tanks, streams, channels, etc. The total gross irrigated area was 13.3 Mha. There was a spurt in protective irrigation works in the first two decades of this century. The total capital outlay on these protective works increased sixfold from Rs. 2 crores in April 1903 to about Rs. 12 crores in April 1921 while the overall outlay on irrigation works, protective and productive together, increased only about twofold from Rs. 40 crores in 1901 to Rs. 79 crores in 1920-21. At the end of this period, the area irrigated was 10.4 Mha by public works and 8.9 Mha by private works in British India and 3.3 Mha in the former princely states, a total of 22.6 Mha.

15.4.3 The Bengal famine of 1943 brought home the urgency of taking steps to face the recurring droughts and of increasing agricultural production to meet the needs of the growing population. The Grow More Food (GMF) Campaign was launched the preceding year. It relied mainly on the development of minor irrigation works and the

restoration of derelict wells and tanks for speedy results. The Famine Enquiry Commission of 1944 emphasised the need to greatly expand private works. This was in line with the recommendations earlier made by the first Irrigation Commission (1901—03) and the Royal Commission on Agriculture (1928). The construction of tubewells in the Indo-Gangetic valley and Gujarat, taken up in the thirties, received a good fillip. Around 1945, the area irrigated from private sources in undivided India, excluding princely states, was 10 Mha, of which 4.4 Mha was from wells.

15.4.4 The progress of development of irrigation in British India in the current century prior to Independence is shown in Table 15.2.

TABLE 15.2

Progress of Irrigation Development in Undivided India excluding Princely States

(net irrigated area in million hectares)

Year	Public sector	Private sector	Total
1900	7.6	5.7	13.3
	(57)	(43)	(100)
1920-21	10.4	8.9	19.3
	(54)	(46)	(100)
1945	13.5	10.0	23.5
	(58)	(42)	(100)

(figures in brackets indicate percentage)

15.4.5 At the time of the Partition in 1947, the net sown area in the country, including the princely states, was 116.8 Mha. Of this 28.2 Mha or 24 per cent was irrigated. On Partition, 18.3 Mha net sown area, of which 8.8 Mha or nearly half was irrigated land, went to Pakistan. Of the balance left with India, only 19.4 Mha or about one-fifth was irrigated. It called for tremendous effort to make up the leeway and meet the requirements of the growing population through irrigated agriculture.

15.4.6 A number of projects were soon taken up after Independence, some of them quite large like the Bhakra-Nangal, the Damodar Valley and the Hirakud. Nearly Rs. 80 crores had already been spent on these projects before the First Plan in which many more projects, large and medium sized, were included. A number of new projects were taken up in every succeeding plan. At the beginning of the Fourth

Plan, the gross irrigated area from major and medium* irrigation projects had risen from the pre-plan area of 9.7 Mha to 16.9 Mha. The anticipation for the end of the Fourth Plan is 19.6 Mha.

15.4.7 The Grow More Food Enquiry Committee recommended in 1952 that in view of the relatively short time it takes to construct them and utilise them fully, new minor irrigation schemes and repairing of existing ones should be accorded a priority in the plan and funds earmarked for them. Construction of tubewells was an important item in the development programme. There has been an increasing stress on minor irrigation, the pace being stepped up from plan to plan. The pace was greatly accelerated during the triennium 1966—69 owing to the failure of the south-west monsoon in most part of the country in the years 1965 and 1966. During this triennium, about 1,57,000 new tubewells were constructed, 2,50,000 diesel pumpsets installed, the number of electric pumps doubled to 10,89,000, besides improving a large number of existing wells by boring or deepening.

15.4.8 Irrigation works depreciate with passage of time. Reservoirs and tanks suffer a loss of capacity through siltation, strainers of tubewells deteriorate and their discharge gets reduced and some of the open wells fall into disuse. The reduction in irrigation due to depreciation has been less marked in the case of major and medium projects but has been substantial in the case of minor works. The progress of irrigation, allowing for depreciation, in major and medium and minor works is shown in Table 15.3.

TABLE 15.3

Progress of Irrigation

(gross irrigated area in million hectares)

	Major and medium	Minor	Total
pre-plan (1950-51)	9.7	12.9	22.6
end of First Plan (1955-56)	11.0	14.1	25.1
end of Second Plan (1960-61)	13.1	14.8	27.9
end of Third Plan (1965-66)	15.2	17.0	32.2
end of annual Plans (1968-69)	16.9	19.0	35.9
end of Fourth Plan (1973-74)	18.8	23.5	42.3

15.4.9 In the First Plan, of the total public sector expenditure, irrigation projects—major, medium and minor—had received a relatively

*In the Report of the Irrigation Commission—1972—Classification of Irrigation Works has been described and discussed. Broadly, irrigation schemes which cost more than Rs. 5 crores each have been classed as major schemes and those below that amount as medium schemes except that those which cost less than Rs. 25 lakhs in the plains or Rs. 30 lakhs in the hills have been classed as minor schemes.

large share, amounting to 18.7 per cent, primarily due to the requirements of a few giant irrigation projects which had already been committed. In subsequent plans, the share has ranged between 9.9 and 11.2 per cent of the total plan expenditure. But recognising the importance of irrigation and particularly that of minor irrigation schemes, large amounts have been made available from institutional sources. Table 15.4 gives, planwise, the total plan expenditure in public sector, the expenditure on major and medium irrigation projects and that on minor irrigation projects. It also gives figures of additional funds made available for minor irrigation from institutional sources. These figures do not include the investment on ayacut development.

TABLE 15.4
Public Sector Expenditure on Irrigation

(Rs. crores)

Plan	Public sector expenditure				Percentage of col. 4 to col. 5	Additional outlay for minor irrigation from institutional sources
	Major and medium irrigation	Minor irrigation	Total irrigation	Total all heads of development		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
First Plan . .	380*	66	446*	1,960	18.7@	Nil.
Second Plan . .	380	95	475	4,600	10.3	28
Third Plan . .	583	270	853	8,577	9.9	100**
Annual Plans (1966-69)	427	314	741	6,625	11.2	205** (anticipated)
Fourth Plan .	1,253	526	1,779	16,201	11.0	500**

* Includes Rs. 80 crores incurred during the pre-plan period.

@ Does not take into account Rs. 80 crores incurred during the pre-plan period.

** In addition, there has been an investment on rural electrification of Rs. 8 crores in the First Plan, Rs. 75 crores in the Second Plan, Rs. 153 crores in the Third Plan, Rs. 237 crores during the annual plans and Rs. 819 crores in the Fourth Plan. There has also been private investment on minor irrigation, which has been estimated to be Rs. 450 crores in the Fourth Plan.

5 GROUNDWATER

15.5.1 The extent of groundwater varies from State to State. Generally, the alluvial tracts are rich and the hardrock areas of the peninsula poor in it. Owing to lack of sufficient data, a precise estimate of the country's groundwater resources has not yet been made. The Central Ground Water Board has, however, attempted a first approximation with the information and data so far available, and has placed it at 27.00 Mham, of which 0.25 Mham in the saline areas is considered

unfit for use. In Section 2 of this chapter we have indicated that on full development of surface water resources and adoption of certain measures for increased infiltration the amount of usable groundwater which may ultimately become available would be of the order of 35 Mham. Of this about 26 Mham would be available for irrigation.

15.5.2 The needs and in consequence the priorities for the development of groundwater resources vary from State to State. In several areas with abundant groundwater, intensive development of it is taking place through various financing arrangements. There are also areas like Coimbatore district in Tamil Nadu, Mehsana district in Gujarat, Ludhiana district in Punjab, where due to over exploitation watertable has been falling. In the coastal areas, uncontrolled development of groundwater is likely to result in irreversible saline infestations. All these areas call for a speedy assessment of groundwater resources so that these are exploited in a planned manner without running the risk of adverse effects.

15.5.3 The expenditure on surveys and investigations of groundwater is only a small fraction of the cost of its exploitation. It is important that these investigations should not be allowed to suffer for want of funds. In the absence of an assessment of groundwater resources in a river basin or sub-basin, the preparation of a master plan for the overall development of its water resources would not be feasible. In the hardrock areas, water balance studies should be taken up immediately in a few selected river basins of moderate size to evolve a methodology which could be applied to contiguous or analogous areas.

15.5.4 The construction of a storage dam affects groundwater table both upstream and downstream of it. We recommend that while planning for a storage scheme a careful study should be made to find out, quantitatively to the extent possible, the effect of constructing the dam on the existing wells downstream. A few years after the construction, the study should be repeated on the basis of actual observations to check on the assumptions made earlier.

15.5.5 It is of utmost importance that all relevant information, particularly strata charts and drilling logs, prepared at the time of putting down drill holes for investigation of production wells, is carefully tabulated, analysed and preserved for future reference. A good deal of money can often be saved by a study of such records in exploiting groundwater in an area. While strata charts are being maintained for State tubewells in practically all the States, no such record is maintained by any department for the private tubewells. We recommend that in the Act that the State Governments may enact for the development of groundwater, there should be a provision that the drilling agency which drills to depths of more than 30 metres must furnish a copy of the drilling log to the state groundwater board for record

and use in subsurface geological mapping. It is further recommended that the state groundwater boards should make a systematic attempt to secure copies of logs of existing private deep tubewells for the same purpose.

Open Wells

15.5.6 Open wells have been in use in the country for irrigation from time immemorial. Their numbers increased as the cultivated area increased. Towards the end of the nineteenth century, 30 per cent of the total irrigation in the country was from open wells, bulk of it in the groundwater-rich alluvial tracts. The first Irrigation Commission emphasised the importance of well irrigation and recommended bringing an additional area of 6.5 million acres under it. The Royal Commission on Agriculture also laid stress on expanding well irrigation. With the Grow More Food Campaign, launched in 1942, a large scale programme of construction of open wells was taken up aided by Government. There has been significant additions to their number throughout the plans, the number rising from 3.64 million in 1956 to 4.47 million in 1961, 5.11 million in 1966 and 6.10 million in 1971.

15.5.7 In recent years, a number of factors gave fillip to open well construction. The earlier construction of these depended largely on a farmer's own initiative and financial resource, assisted to a limited extent by taccavi loans. The introduction of high yielding varieties, encouragement of multiple cropping, an incentive oriented price policy, whipped up in the cultivator the desire to have at his command an irrigation source from which he could water his crops at the right time and with the required quantity. To a cultivator this freedom of choice of time and quantity is of immense value. This he can get only by owning the source, whether it is an open well or a tubewell. Easy credit facilities from institutional sources have helped the farmers a great deal in this matter. The rapid expansion of rural electrification which enabled the farmers to replace, to a considerable extent, the less efficient man or animal operated water lifting devices, by electric pumps has given the programme of groundwater development a further push.

15.5.8 The new wells constructed during any period do not make an addition to the total number to the full extent, as during this period some wells go out of use. In areas where canal irrigation is introduced, some wells tend to go out of use no sooner the less expensive flow irrigation water becomes available. In many cases, the wells get restored on increase of intensity of cropping for which canal water may not suffice. There can be several other reasons for open wells falling into disuse. The well sides may collapse and the damage may be beyond economic repairs. The groundwater table may drop leaving the

wells dry. Fragmentation of holdings served by a well may lead to diluted responsibility for its upkeep and, therefore, to indifference to its proper maintenance resulting in its dereliction. Disputes regarding the use of water may also lead to abandonment of a well. It would be desirable that States should make an enquiry into the causes where a substantial number of wells have gone out of use and evolve remedial measures so that the investments already made on these wells are not altogether wasted. If some credit is required for restoring an abandoned well, it should be provided, as it would generally be cheaper to restore an old well than dig a new one. Also a new well means some area taken out of cultivation. The problem of abandoned wells is quite sizable. For example, in March 1971, of 1,111,000 wells in Madhya Pradesh, 615,000 were irrigation wells, 369,000 domestic wells and 127,000 abandoned wells. Thus 11.4 per cent wells in the State were out of use. Similar information for other States is not readily available but the broad pattern may not be different.

15.5.9 Except for Punjab and Haryana and possibly Tamil Nadu and Karnataka, in all the States more wells are operated with indigenous water lifting devices like Persian wheel, *charas*, *moat*, etc. than with pumps. In March 1969, there were about 4.09 million wells operated with indigenous lifting devices in the country and 1.66 million with pumps. Since then the number of the latter category has increased, but that of the former still predominates. Installation of a pump on a well is economical only if the area to be irrigated is not too small. A study conducted by the Indian Institute of Socio-economic Studies, Bangalore, showed that it was not remunerative to install pumpsets on wells for irrigating less than one hectare in a season. A census taken by the Directorate of Agriculture, Madhya Pradesh in 1972, showed that in Indore district where 80 per cent of the wells were fitted with pumps, the average area irrigated per well was 1.54 hectare while in Surguja district where 98 per cent wells were operated with indigenous lifting devices, the corresponding figure was only 0.13 hectare. The average for the State worked out to be 0.88 hectare.

15.5.10 There are several advantages in replacing indigenous lifting devices by pumps. Where the holding is not too small and is more than, say a hectare, the bullock power thus released can be gainfully utilised for other purposes. It also saves the farmer some time as with a larger discharge of 25,000 to 35,000 litres per hour which a pump generally gives, it takes less time to irrigate a field. With indigenous lifting devices the stream size in the watercourse is generally small, a Persian wheel delivering only about 10,000 litres per hour, which leads to higher water losses not only in conveyance but also in the field thereby requiring the lifting of a larger volume of water than with pumps. In areas where groundwater is not plentiful, the higher loss of water

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assumes added seriousness. However, it is not normally advisable to install pumpsets on wells with recuperation of less than about 120,000 litres per day (24 hours). On wells with low yields boring and deepening become necessary before a pump is installed.

Tubewells

15.5.11 By far the larger number of irrigation tubewells in the country are privately owned and tap shallow aquifers. At the end of March, 1969, while there were only 15,000 State tubewells, the private ones numbered 246,000, though of smaller size. Table 15.5 shows the details of the progress of minor irrigation programmes in the Plans:

TABLE 15.5
Progress of Minor Irrigation (Groundwater)
(number in thousand)

Item	Pre-plan	End of First Plan	End of Second Plan	End of Third Plan	End of 1968-69	End of Fourth Plan
wells in use	N.A.	3,624	4,474	5,111	5,908	6,841
diesel pumps	66	123	230	465	721	1,752
electric pumps	21	56	199	513	1,089	2,442
private tubewells including filter points	21	30	49	113	246	782
State tubewells	3	7	10	13	15	21

NA—Not available

It would be noticed that the growth of private tubewells has been particularly noteworthy from Third Plan onwards. This rapid expansion came in the wake of the spurt in the application of science and technology to agriculture. The use of seeds of improved varieties, fertilisers, pesticides and scientific methods of cultivation give increased economic returns if timely and adequate irrigation supplies are available. Private tubewells provide these. The stepping up of the programme of rural electrification and the provision of credit facilities have been the other contributory factors. Private tubewells have certain advantages over State tubewells. A farmer having made an investment on a tubewell feels deeply interested in making the maximum use of it. If any part of the equipment goes out of order, he loses no time in getting it repaired. On State tubewells, on the other hand, there are at times inordinate delays in repairs due to departmental procedures and indifference on the part of tubewell operator. The consequences become serious during periods of keen demand.

15.5.12 State tubewells generally tap deep acquifers and give, on an average, a discharge of about 135,000 litres per hour

and cost about Rs. 1.5 lakhs excluding cost of electrification. These irrigate a gross area of 80 to 100 hectares, the net irrigated area being about 20 per cent less. These are run for 2,000 to 3,000 hours per annum and have a useful life of 20 to 25 years. Larger tubewells upto a capacity of 700,000 litres per hour have also been sunk. Private tubewells are mostly shallow and have a discharge of about 30,000 litres per hour. These are generally run between 500 and 1000 hours per annum and irrigate 4 to 8 hectares. The life of shallow wells ranges between 5 and 15 years. In the delta areas, filter points with 10 to 12 metres bore depth and yielding less than 25,000 litres per hour are in use. In the red soil area in South India, an open well gives a discharge of 70,000 to 230,000 litres per day and has a useful life from 50 to 100 years. The deep tubewells, because of the high cost involved and the skill and equipment required for them are best undertaken by the State ; all other groundwater development should preferably be in private sector which would also provide the farmers with greater flexibility in the use of water. They should be assisted with credit facility, technical knowhow and equipment to the extent necessary. Private tubewells are smaller and run for fewer number of hours in a year than State tubewells and are, therefore, less economic in investment. Jointly owned private tubewells, however, would run for more hours than individually owned ones and should be encouraged.

15.5.13 A recent innovation in Bihar is the low cost bamboo tubewell which irrigates 2 to 4 hectares. A large number of these were installed in the districts of Purnea and Saharsa and are reported to have given good performance for over 4 years. These tubewells are operated with mobile diesel pumps which are available on hire also. For rapid exploitation of groundwater where shallow aquifers exist, these low cost tubewells hold promise, but only where there are no interfering clayey layers.

15.5.14 Tubewells can be diesel operated or electrically operated. State tubewells are mostly electrically operated but nearly a third of private tubewells are diesel operated notwithstanding the fact that electric pumps are cheaper both in capital and operating cost. This situation has arisen because of inadequate and unsatisfactory supply of power. The persisting shortage of power in most parts of the country, particularly in North India where groundwater resources are abundant, has hampered the rapid growth of electrically operated tubewells and farmers keen on having their own source of irrigation have turned to the more expensive diesel pumpsets. Electric pumpsets are generally trouble-free and easy to operate, but due to recurring

low voltage in many areas motors have been getting burnt up thus adding the cost and seriously interrupting irrigation. One advantage of diesel pumps is that they can be conveniently moved from one tubewell to another, and many farmers use a pumpset on more than one tubewell thus saving on cost. Even so, the overall cost is much higher than for an electric pump. A recent study (March 1972) of private shallow tubewells made by the Water Resources Directorate of Punjab showed that the average cost per hour of running diesel operated tubewells was nearly double that of the electrically operated ones. Since then the price of diesel oil has risen considerably and, therefore, the cost differential is now even greater. In view of the economic superiority of electric pumps, we recommend that power requirement for irrigation purposes should be met on a priority basis and an unfluctuating and uninterrupted supply of it ensured.

15.5.15 As electrically operated tubewells and electric pumps on open wells are more economical than diesel operated ones, it is important that the programmes of constructing power distribution lines and that of construction of State and private tubewells and the installation of pumps on open wells should be properly coordinated. In the event of the programme of power lines lagging behind, there would be little option with the farmers but to go in for the less economical diesel operated pumps. The present tendency of the farmers to prefer diesel pumps because of the shortage and unsatisfactory nature of power supply, it is hoped, will disappear before long with the improvement in the power position.

15.5.16 The present groundwater development in the country is to a large extent uncontrolled. As a result there has been overpumping in several areas, creating serious problems. Overpumping results in permanent lowering of the groundwater table. The progressive depression of the watertable leads to increasing pumping head, reduced discharge and high costs making groundwater utilisation ultimately uneconomic. In a scramble for water, people go in for larger and deeper well bores or space the tubewells and open wells closer than they should. For example, in Coimbatore district in Tamil Nadu, where groundwater is extracted from the rocky strata by constructing large open wells with bores made to tap water from waterbearing fissures and crevices, farmers have been vying with each other in deepening these wells in an attempt to draw more water to their own wells. As soon as one well is so deepened, the neighbouring wells get affected and these in turn are deepened at considerable cost. In a situation like this, the State must intervene and rationalise the extraction and distribution of the groundwater. In the

coastal areas overextraction of sweet water can lead to an irreversible intrusion of saline water.

15.5.17 The areas which have already been noticed as affected by overpumping are: the coastal districts of Andhra Pradesh; Bihar Sharif areas in Bihar; Anjar-Khedoi and Viri areas of eastern Kutch and Mehsana district in Gujarat; possibly Karnal district in Haryana; Ludhiana district in Punjab; Jhunjhunu district and Kharkar basin in Rajasthan and Coimbatore, Salem, Madurai and North Arcot districts in Tamil Nadu. In overexploited areas, apart from restricting further exploitation of groundwater for only domestic and industrial use, steps should be taken to recharge it by all practicable means. The legislation for regulating and controlling the use of groundwater is urgent in States where overexploitation is already in evidence. A Model Bill was circulated to the States by the Union Ministry of Agriculture[1] in December 1970. The States should expedite the enactment.

15.5.18 With rising demand for the use of groundwater and its increasing exploitation, the question of right to it arises. It is to be noted that all groundwater vests in the Government and that right to it cannot be acquired by prescription under the Indian Easement Act, 1882. Also, restrictions imposed in public interest on the use of groundwater by the existing users do not entail payment of any compensation*. In any groundwater basin, the available groundwater, after allowing for non-agricultural requirements, should be deemed to pertain to the land and each holding, weighted in respect of the quality of the soil, should have a legitimate right to a proportionate share of the water. Therefore, if a farmer constructs a private tubewell which yields more water than the share of his holding, then it should be permissible for the farmers having contiguous holdings to avail of their share of tubewell water on payment of share cost. If surface water is available in the basin, that should be accounted for in apportioning the shares. For making such an apportionment, it would be necessary to make an assessment of the water available in the basin, classify the land and lay down norms. In the legislation for "Groundwater Control and Regulation" it would be necessary to make a provision for the sharing of groundwater by the entitled farmers. The sharing can be enforced in the same manner as canal water distribution is enforced through 'Warabandi'. The enforcement will, of course, have to be done by the organisation to be set up for groundwater development as envisaged in the Model Bill.

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1 Now Ministry of Agriculture & Irrigation.

* These legal aspects were conveyed to State Governments in the Ministry of Agriculture D.O. letter No. 12-12/69-MIT, dated December 18, 1970.

6 DEVELOPMENT OF WATER RESOURCES

Certain Policies in Development

15.6.1 Comprehensive planning of use of water resources : In view of the complete inadequacy of water resources to meet the future agricultural and other requirements in many parts of the country, it becomes a matter of great national importance to conserve and utilise them most judiciously and economically. As has been pointed out in the Report of the Irrigation Commission (1972), there has to be proper planning for water use and this has to be related to a defined area or region. A river basin, and in the case of large rivers a sub basin, is a natural unit for such a plan, as it has a defined watershed boundary and within it there is an interrelationship between the surface and groundwater resources. The river basin plan should present a comprehensive outline of the development possibilities of the land and water resources of the basin, establish priorities in respect of water use for various purposes, indicate the need for earmarking water for any specific purposes and indicate *inter se* priority of projects. These plans would require to be periodically reviewed and revised in the light of changing needs and availability as development advances. The Irrigation Commission has recommended that comprehensive river basin plans should be prepared. We strongly support this recommendation.

Water use for Irrigation

15.6.2 Land and water are the two most important natural resources of the country. The best use of the two together is necessary for the maximum benefit of the people. These two resources are not evenly matched in most parts of the country and the one which is short becomes a constraint on the fuller use of the other. In the Brahmaputra valley there is not enough land to make full use of the enormous flows of the river and abundant groundwater. There are some other areas also where water is plentiful. In such a situation obviously multicropping is indicated to get the maximum production per unit area, and water intensive crops like rice and bananas can be grown.

15.6.3 In most parts of the country, however, water resources are insufficient to meet the irrigation requirement of the cultivated land. That being so, it becomes necessary to so utilise the available water in these areas as to secure the maximum crop production per unit of water, extending at the same time the benefit of irrigation to as

many farmers as is technically and economically feasible. This requires the adoption of the best technique of irrigating the field, minimising waste of water in storage and conveyance and adoption of cropping patterns which, taking into account the constraint of limited irrigation supplies, would give the maximum benefit.

15.6.4 The hard-core drought areas comprising[1] about 16 per rent of the total geographical area of the country and having over 11 per cent of its population have a different set of considerations in the use of their very scarce water resources. Here not only the rainfall is very scanty but its year to year variation is more pronounced than elsewhere. In a lean year of rainfall the hardship in respect of drinking water greatly increases. Cattle suffer most both for want of drinking water and fodder. People of the area already economically low down do not have the purchasing power to buy sustenance from elsewhere. These conditions weigh in formulating the policy regarding the use of water in these areas. The highest priority in water use is indisputably for domestic purposes. The next priority may be given to industries in view of their small requirement and greater income-generating potential. The remaining water should be utilised for agriculture and this is best done for growing water-thrifty crops and fodder for animal husbandry to secure the maximum income per unit of water. Also, the benefit of irrigation has to be provided to as large a section of the community as is economically feasible. This implies keeping the irrigation intensities low and treating the irrigation works as 'protective'. Needless to say that moisture conservation practices assume great importance in these areas. It has to be recognised that here irrigation with only local water resources must remain precarious and that dependable irrigation would be possible only with surface water brought in, even at a sacrifice, from other basins which have better water resources. When irrigation water is thus brought in, it should serve compact blocks. This is necessary in order to reduce the effect of advection* which on a sunny day may extend upto 85 metres from its boundary in the irrigated block, where unless compensated by additional dose of irrigation, yields would be affected. The blocks should be dispersed over a large area to benefit large number of farmers. It would be a good arrangement for farmers to have some irrigated and some unirrigated holding rather than a few having all the irrigated land. In these areas, fewer waterings can be given to crops than are required for maximum yields, but the depth of each watering should be sufficient to keep the salts, if any, down the soil profile.

1 Report of Irrigation Commission (1972).

* Advection is the transfer of energy resulting from horizontal heterogeneity. Source — Canadian Agricultural Engineering col. 9, 1967.

15.6.5 In most parts of the country crops can be raised without irrigation during the rainy season. But where rainfall is inadequate or erratic, yields are poor. If irrigation supplies are made available for timely sowing and making good the deficiency in rainfall, good yields can be secured. Often during a prolonged break in rain, a small support from irrigation supplies makes all the difference between crop failure and its successful maturing. Irrigation supplies can go a long way if utilised to supplement rain. For example, rainfed rice is grown extensively in the central region of the country comprising eastern part of Uttar Pradesh, Bihar, Orissa, Madhya Pradesh and the contiguous parts of Maharashtra. In most of this area good rainfall occurs only in two months, July and August, while the crop requires copious water for four months. Given irrigation facilities to supplement rain water excellent yields can be secured here, particularly as this enables the timely and proper use of inputs like fertilisers, etc. In view of this we recommend that irrigation projects should be planned to irrigate maximum area during the rainy season by supplementing rain.

15.6.6 Evaporation and transpiration losses are lowest during the winter months and are highest during the four months of April to July. During the hot season, therefore, the use of irrigation supplies is less economic than in the rest of the year. It is, therefore, advantageous to bring as much area as possible under irrigation during winter months or the eight months excluding hot weather. It is recommended that this aspect should be borne in mind in planning irrigation projects.

Conjuctive Use of Surface Water and Groundwater.

15.6.7 There are tracts in the country notably the Indo-Gangetic valley, that are rich in both surface water and groundwater and it becomes a matter for consideration as to how best the two can be utilised for irrigation. Surface water is more susceptible to vagaries of rainfall than groundwater ; the latter, in consequence, is more dependable. In most areas, surface water is more plentiful than groundwater, but on many canals the supplies are erratic and inadequate. For modern agriculture with high value inputs, it is important that irrigation supplies should be adequate, timely and dependable. It is in this context that supplemental irrigation with groundwater has been finding increasing favour in existing canal areas.

15.6.8 There are several ways in which the combined use of surface and groundwater can be made in canal commands. Groundwater can be fed into canals to augment their supplies, as has been

done in Haryana. It can be used directly for irrigation during periods of low canal supplies or canal closures, as also for irrigating pockets in a canal command especially where the terrain is uneven. Tubewells for augmenting canal supplies have to be State owned since canals are State owned. Those for irrigating high patches in canal command can be State owned or privately owned. But for supplemental irrigation in canal irrigated areas, groundwater is best exploited by farmers themselves either by sinking private tubewells or installing pumps on open wells. Canal water charges, with few exceptions, are very low and cultivators find it advantageous to use canal water to the extent available, pay for it and save on pumping cost. In all canal command areas wherever suitable groundwater is available, farmers should be encouraged to harness it by assisting them with credit facilities, technical advice where required, and in the actual execution of their schemes. These matters are dealt with further in a later portion of this Chapter.

15.6.9 In our Interim Report on Modernising Irrigation Systems, we pointed out that there was ample economic justification for investment on groundwater in canal served areas, and had recommended that there should be an organised attempt to encourage it. In this connection we further recommended that the existing restrictions in exploiting groundwater in the canal commanded areas should be reviewed with a view to relaxing them to the extent feasible in the interest of larger conjuctive use of surface water and groundwater and increasing the scope of irrigation.

15.6.10 There are several areas in the Indo-Gangetic plains and the red soil tracts of the peninsula where water may not be available in the rivers or streams for *rabi* irrigation but where *kharif* irrigation can be provided with rainy season flows by constructing barrages and *kharif* canal systems. Apart from giving a good *kharif* crop, this irrigation would augment the groundwater in the area which can later be utilised for some *rabi* irrigation through shallow tubewells or open wells. If the *kharif* supplies are utilised for irrigating rice crop, the resulting groundwater charge would be greater and more water would be available for *rabi* irrigation. This would be a good conjuctive use of surface and groundwater. As no expensive storage dams would be involved in this arrangement, the *kharif* irrigation would be relatively inexpensive. The economics of this conjuctive use would, in most cases, be quite sound. We recommend, therefore, that schemes for such conjuctive use should be investigated and where found economically sound taken up for implementation.

Irrigated Plantation

15.6.11 In low rainfall regions of the country, the paucity of soil moisture during most part of the year inhibits tree growth. In these areas, there is shortage of water not only for irrigated agriculture but also for horticulture, plantations and other uses. These sparse tree growth results in shortage of fuelwood, small timber and tree fodder. This, in turn, creates pressure for exploiting whatever trees are there. These get heavily lopped and often felled before they are fully mature. This destructive process has to be arrested by meeting the demands in an organised and orderly manner.

15.6.12 In formulating irrigation schemes, it is seldom that a thought is given to raising irrigated plantation. There seems to be a general impression that it is uneconomic to provide irrigation to woodlots. Raising of irrigated plantation has to be considered not only from a commercial angle but also for meeting a very important pressing need. If fuel wood is not available in an area, people would be driven to use cowdung and whatever other combustible material they can lay hands on for meeting their fuel needs. Also, it should not be assumed that raising irrigated plantation is unremunerative. In Gujarat State, at Vatva an enterprising and progressive farmer planted eucalyptus on about two hectares of irrigated land, growing cotton in-between the lines. He has since then extended these plantations and covered about 32 hectares of irrigated land. He expects to extract small size timber when five years old and hopes to make an earning of over Rs. 5,000 per hectare per annum. In Haryana, irrigated plantations have been raised in an area of about 4,000 hectares in Saraswatipur. This is an outstanding example of irrigated plantation in a low rainfall area.

15.6.13 In the irrigated areas of north India and elsewhere in the low rainfall areas, several species can be suitably raised depending on the site conditions. These are mainly *dalbergia sissoo, morus alba, albizzia lebbek, melia ezedarach, poplars, trewia nudiflora, acacia arabica, eucalyptus hybrid* etc. There is very little information on the water requirements of these species. This is a matter which needs investigation to ensure economic use of irrigation supplies for the purpose. Trees do not need irrigation throughout their life. Once well-established, they can tap the subsoil moisture effectively because of their deep root system. Normally, it is necessary to water the plants only in the initial two to three years, though subsequent watering would promote their growth. In Pakistan, *dalbergia sissoo and morus alba* plantations have been irrigated only from April to October. In the cooperative experiments carried out at Chichawatni and Khanewal,

both in Pakistan, irrigation delivered to plantations ranged between 60 to 90 cm delta.

15.6.14 We recommend that in formulating new irrigation projects particularly in low rainfall areas, an attempt should be made to create irrigated plantations in compact blocks. It might be mentioned that blocks smaller than 200 hectares become expensive in supervision, fencing and exploitation. The irrigation charges can be per watering or per season and need to be kept reasonably low as a promotional measure. The area of irrigated plantation would normally be a small fraction of the total command area in a project.

Investigation and Project Formulation

15.6.15 The scope of an irrigation project is determined primarily by the quantity of water that is available for the purpose. To ascertain that, rainfall, river discharge and ground water data have to be compiled and analysed for a fairly long period, say, 30 years. Where observed data for a sufficiently long period are not available, the margin of error in project formulation is more. Considering the long period for which data are necessary, it is important that sufficient observation stations should be set up without loss of time in all river basins where these are inadequate. The investigations of an irrigation project have to be thorough and must not be abridged or curtailed in an endeavour to produce a project report speedily. That can lead to infructuous expenditure and delays during construction. Also the best alternative might not get adopted in a hurriedly commenced project with incomplete investigations. It has to be borne in mind that it is not the date of commencement of a project but the date of accrual of benefits that is important. The cost of investigation of a project is only a small fraction of its construction cost. It is generally less than one per cent for a storage dam and less than five per cent for an irrigation system worked out in detail. Investigations, however, take a fairly long time. It is, therefore, important that a number of fully investigated projects should be kept ready to choose from to suit the availability of resources and fulfilment of other considerations.

15.6.16 Hitherto, reports on irrigation projects have been prepared in two parts, viz., engineering works right from the storage or diversion works to watercourses and including drains, and command area development. It is obvious that unless the development of command area is also completed, full benefits cannot accrue from the project. The Command Area Development Programme, however, comprises some one-time items of work such as land-levelling and shaping, construction of watercourses, field channels and fields drains, and other

Irrigated Plantation

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programmes concerning the Departments of Agriculture, Animal Husbandry, Forest, Fisheries and Cooperation. In view of the diverse nature of works involved in command area development, we recommend that an irrigation project should be formulated in three parts as under :—

PART I—all engineering works from source of supply up to outlets, and drains.

PART II—all engineering works in the command area comprising land levelling and shaping construction of watercourses lined or unlined field channels, field drains and farm roads.

PART III—all other items pertaining to agriculture, animal husbandry forestry, fisheries and cooperation.

The project report should be considered for sanction in its entirety and not in parts. The project report should also identify the critical areas in the catchment that would require treatment on a priority basis in order to reduce silt yield from those areas, but the cost of their treatment need not form part of the irrigation project.

15.6.17 For Part I of the Report, meteorological data have to be compiled and analysed, hydrological observations carried out and computed, geological and topographical investigations undertaken, preliminary soil surveys done and other explorations and investigations necessary for planning and designing the engineering works made. For Part II, contours have to be plotted on large scale village maps, drainage lines and other topographical details shown and detailed soil surveys undertaken. For Part III, enquiries have to be made in respect of the present status of the relevant items and proposals drawn up for their development and expansion, setting down the measures that would need to be taken. In Chapter 16 on Command Area Development, we have discussed in some detail the various items pertaining to Parts II and III and have indicated the organisations which would be appropriate for dealing with them. Here we wish to emphasise that it is of utmost importance that investigations of all the items for the project report are undertaken simultaneously. Normally the Irrigation Department has to carry out reconnaissance and preliminary investigations. But once the decision is taken to prepare a project report all the concerned departments should be immediately notified of it so that they in turn organise the investigations which they have to make. In the past, in most cases, this was not done and investigations pertaining to Parts II and III were taken up much later than those for Part I. In several cases Parts II and III received attention only after construction of Part I commenced. This resulted in an inordinate delay in the utilisation of irrigation supplies on water becoming

available at the outlets. This lag has been responsible not only for poor production in the project areas during the initial years, but also for damage to the soil in the command area by the water allowed to run to waste. We are glad to note that the Planning Commission has already advised all the States that, from April 1975, only projects formulated comprehensively on the above lines would be accepted for consideration.

Reduction of Water Losses

15.6.18 Lining of channels: In our Interim Report on Modernising Irrigation Systems we drew attention to the need and importance of lining channels to save water for extending irrigation, where economically feasible. In 1960, at a symposium on canal lining, it was stated that by lining channels, enough water could be saved to irrigate an additional six million hectares. Many more unlined canals have since been constructed and the scope of lining is now larger than before. No fresh appraisal of the scope has since been made. But even assuming that the above stated figure is somewhat optimistic, it is obvious that the scope for saving water is large indeed.

15.6.19 It has been roughly estimated that a third to a half of the seepage water from channels gets absorbed in the top layers of adjoining soil and is lost through evaporation and transpiration. Of the remaining quantity that reaches the groundwater table, only about 70 per cent can be drawn out locally. The rest regenerates itself elsewhere where it may or may not be utilisable. Thus, only a third to a half of the seepage loss can be retrieved by pumping. Against this, in most cases lining would save about 80 per cent of the loss. Studies have shown that the capital cost of a pumping scheme would be about the same as, if not more than, that of lining channels to save that quantity of water. But the cost of pumping would be considerable. It may, in a period of two years, be as much as the total cost of lining the channels. Thus both from consideration of cost and the quantity of water saved, lining is to be preferred. In remodelling an unlined irrigation system, if lining would affect the existing wells and tubewells, its economics should be carefully examined taking into consideration the reduction in the value of the investment made on them arising from the impairment of their capacity.

15.6.20 It is not always possible to provide lining to channels once these are opened for irrigation, particularly the larger ones carrying water for the greater part of the year. Lining of channels should, therefore, be considered at the project formulation stage. In determining the economics of it, not only the current value of water, but

its value years hence when new water resources would become scarce, should be considered, keeping in view that lining of the larger channels later may not at all be feasible.

15.6.21 A large variety of lining materials have been tried in the country. Amongst these may be mentioned *in situ* concrete, precast concrete slabs, stone masonry, brick masonry, asbestos cement or clay tiles, asphaltic concrete or membrane, bentonite, films of plastic, rubber or other synthetic materials, etc. Cement mortar protected by brick tiles has been extensively used in North India. Each type has its advantage and limitation and no particular type can be considered suitable in all situations. Impermeability, strength durability, ease of repair, ready availability and cost are the more important considerations in the choice of lining material. Lining should be able to resist damage from farm animals, rodents and weed growth. A recent innovation which has been tried with successful results in Australia, USA and certain other countries consists of dissolving an oil based material (trade name SS 13) in water to form an emulsion and letting it soak into the channel bed and sides, compartment by compartment. The emulsion forms a colloidal substance in the soil in a thickness of about a metre and renders the channel fairly impervious. The cost compares favourably with other methods of reducing seepage. Soil compaction is yet another technique recently introduced for reducing seepage losses.

15.6.22 In general, seepage losses on small channels are relatively greater because the ratio of wetted area to volume of water carried is higher. It might be stated that depth of water in a channel has only a marginal effect on the rate of percolation. Poor maintenance so common on the smaller channels and in many cases, rat holes add to the losses. The lining of smaller channels, therefore, bestows greater benefit and is easier to carry out. But it can be argued that the smaller channels generally run for less time, which counters these advantages to some extent. A recent report on the Dhorighat Pilot Project for Soil and Water Management in Azamgarh district, Uttar Pradesh, brought out that in that project area it was not economical to line field channels which served an area of less than 6 hectares or which ran for less than 400 hours in a year. In working out the economics of lining channels, both their size and running time are important considerations besides the permeability of the bed and side material.

15.6.23 For distributing water to the fields, the use of underground pipelines has several advantages and is being increasingly adopted by farmers in several States. When properly laid and made leakproof, the pipelines require little subsequent maintenance. Unlike

water courses and field channels, these offer no obstruction to farming operations. As these can operate under some pressure, these can be laid on undulating terrain without having to follow a contour or requiring levelling of land. These are particularly suitable for areas served by wells or tubewells. Pipelines cost more than lined water courses, but in many situations the saving of high value land, low cost of maintenance and adaptability to uneven terrain make them amply worthwhile. Where land cost is Rs. 15,000 per hectare or, more, it would be desirable to make a comparative study to see whether pipeline would not be the more economical means of conveying water apart from its other advantages.

15.6.24 The lining of water courses has a good employment potential spread over a large rural area. A hectare of irrigated land normally requires about 75 metres of water course. If half of the irrigated area of 20 Mha at present served by major and medium irrigation projects is to have lined water courses, about 750 thousand kms would have to be lined. This would cost about Rs. 600 to 700 crores at 1972-73 price level and provide employment of more than a million man-years.

15.6.25 Owing to financial and other constraints, it may not always be feasible to take up at one time the lining of all the channels which may need it and work may have to be phased. The Commission recommends that in such a situation the priority should be as under :

(i) On new projects and projects being remodelled, channels which are designed to run constantly or most of the time should be preferred because of the difficulty and in some cases unfeasibility of lining them later once they are opened for irrigation.

(ii) On existing projects, the smaller channels including water courses should be preferred for reasons given in paragraph 15.6.22. These lend themselves better to the spreading out of the programme over a larger area and longer period.

15.6.26. For deriving full benefit of lining water courses, certain other steps need to be taken in advance or concurrently. Lining is best taken up in conjunction with land improvement and consolidation of land holdings, so that the water courses may be realigned to suit any changed disposition of land holdings and the new levels of reshaped land. In fact, the programme of lining should form part of a wider programme of improvement of agriculture in an area.

Reduction of Evaporation Losses in Reservoirs

15.6.27 In a storage irrigation scheme, there is considerable evaporation loss from the reservoir. The loss from a unit area of water surface varies from place to place and month to month as it is governed by temperature, radiation, humidity and wind velocity. Evaporation in the hot months of May and June can be two to five times that in the winter months of December and January. The annual evaporation can be 350 cm to less than 150 cm, depending on the place. For a given quantity of impounded water, the percentage loss would be higher if stored in a shallow reservoir than in a deep one.

15.6.28 In areas where evaporation losses from reservoirs are particularly high, and these are the areas where water is most precious, attempts have to be made to reduce this loss. Experiments have been under way in several countries like Australia, Brazil, Israel, USA and also at a number of research stations in India, on the use of substances like cetyl alcohol as an evaporation retarder. These substanes form a monomolecular layer when spread over the surface of water. But they are usually too weak to withstand surface winds. In more recent experiments made on small reservoirs in Western Australia, Rhodesia and South Africa, with tablets of polystyrene foam covered with protective paint, better success is reported to have been achieved than with monomoleuclar films. It is important to intensify research on evaporation retarders with newer materials and techniques in order to make the saving of water economically worthwhile. This would be a suitable subject for a multidisciplinary research project, sponsored centrally.

15.6.29 The manner in which a storage reservoir is operated has a bearing on its evaporation loss. The rate of evaporation is highest during the hot period before the rains. The smaller the quantity of water in the reservoir during this period the lesser is the evaporation loss from the reduced water surface. In larger reservoirs space is invariably provided for dead storage and the reservoir is seldom depleted below this level. Even if no water is retained in the reservoir for irrigation during the hot weather, there would be evaporation loss from the dead storage area. This would, however, be smaller than with water in the reservoir for irrigating hot weather crops. The difference may not be large. Also it would appear desirable that in most reservoirs water should be carried over through hot weather for raising nurseries for timely sowing of rice for better yields, or for timely sowing of such other crops as can later be sustained by rain alone. Where a reservoir has to be operated also for power generation, carrying water in it through hot weather becomes inevitable. But a very large

number of tanks in the country get almost completely depleted before the rains come to fill them again. On some of these, water is carried through hot weather, either for raising hot weather crops or providing irrigation to perennial crops. In view of the heavy evaporation losses during these months, the economics of this mode of tank operation should be carefully examined. It may be advantageous in such cases either to change the cropping pattern and possibly crop species or make use of groundwater, if available.

Tank Irrigation

15.6.30 According to available estimates, at the commencement of the planning era there were about 5 lakh tanks in the country, of which about 46,800 had a command area less than 40 ha each. These tanks are mostly located in Andhra Pradesh, Karnataka, Orissa, Tamil Nadu and West Bengal. In 1950-51, the net area irrigated from tanks recorded was 3.6 Mha and this increased to about 4.5 Mha by 1956. This has remained more or less steady since then.

15.6.31 Many of the tanks are in a state of disrepair mainly because of silting of beds and breaches due to inadequate surplusing arrangements or bad maintenance. There are three agencies responsible for maintenance of different tanks viz., (a) Government, (b) *panchayati raj* institutions and (c) individuals. In the case of departmental maintenance, the annual maintenance grants often fall short of the requirements and even these are not judiciously utilized in every case. The erstwhile Madras State (now Tamil Nadu) had evolved a system of routine inspection of tanks called the circle system. Under this system, each tehsil was divided into a number of circles and engineers made a detailed inspection of each tank in the circle by rotation at a frequency of once in five to six years and carried out the necessary repairs. There is need to introduce a system of this type in all the States which have fairly large tank irrigation.

15.6.32 In Tamil Nadu, there is a legislation called the Madras Compulsory Labour Act, 1858 (Kudi Marammath Act) to legalise compulsory labour for certain maintenance jobs. In the prevailing circumstances, neither the Government nor the local bodies are in a position to enforce such regulations. The entire maintenance work has, therefore, to be carried out on payment basis. Where panchayats are responsible for the maintenance of tanks, they should raise sufficient financial resources through water charges for satisfactorily maintaining the tanks and should employ sufficient staff for the purpose.

15.6.33 In some States, for example, in Chota Nagpur region and Santhal Paraganas of Bihar and Chattisgarh region of Madhya Pradesh,

although on abolition of *zamindari* the rights in respect of *ex-malguzari* tanks vested in Government yet the beneficiaries had permanent irrigation rights by virtue of a legal document called *'Fard-abpashi'* in Bihar and *'Wajib-ul-arz'* in Madhya Pradesh. The beneficiaries always claimed irrigation rights without in any way being under an obligation to the Government. Government has thus been finding it difficult to undertake renovation and regular maintenance of such tanks because even after incurring expenditure it has not been able to levy water charges on the beneficiaries. There is need for a suitable legislation to remove this anomalous position.

Intensity of Irrigation and Channel Design

15.6.34 Intensity of Irrigation, in irrigation parlance, is the sum total of the area irrigated under different crops in a year expressed as a percentage of the culturable commanded area. The intensity which can be attained with a given quantum of water, depends on the duration of the crops irrigated, the number of waterings given and the mode of application of water in the field. Thus, a single long duration crop may require as much water as two crops of short duration. In the case of the latter, the intensity would be twice that for the former. If the fields are level and well prepared, and irrigation is done in a most suitable manner, or if sprinkler irrigation is used, then with the same quantum of water, a larger area can be irrigated and higher intensity attained. In many areas in a State because of their location in respect of water resources, or the paucity of water, crops have to remain rainfed. On the other hand, in pockets of ample water supply, as on a good tubewell, irrigated crops can be raised practically throughout the year. Thus the local intensities in pockets can be well over 200 per cent.

15.6.35 In the past, on several irrigation projects having high water allowance, waterlogging was experienced. But if groundwater and surface water were developed side by side, and proper drainage were provided, this danger would have disappeared. It is envisaged that in the future development of water resources for irrigation, there would be conjunctive exploitation of both surface water and groundwater. Where the possibilities of groundwater development are meagre as in clayey and black soil areas, it becomes imperative to provide adequate drainage to obviate the ill effects of irrigation.

15.6.36 The adoption of high intensity in a project makes it more compact by reducing the commanded area and in consequence lowers the project cost. The conveyance water losses are also reduced but if channels are lined, this does not remain a significant factor. High

intensities enable the farmer to derive the maximum economic benefit from his land and provide continuous gainful agricultural employment. The raising of more than one irrigated crop in any area leads to the better use of inputs like fertilisers and improved implements and also of residual soil moisture from the previous crop. Where area is limited and water ample, the adoption of high intensities is obviously called for. But if the available water can physically serve a large commanded area other considerations arise. A high intensity of irrigation in such a case would benefit fewer farmers but in a large measure than otherwise and that would accentuate social disparity in the farming community. Here the higher irrigation intensity would not give any increased overall production as the gross irrigated area would be determined by the available irrigation supplies and not irrigation intensity. The irrigation intensities would vary from project to project and may range between 150 and 70 per cent on the basis of conjunctive use of surface and groundwater. Keeping the intensity lower than about 70 per cent would affect the viability of small holdings.

15.6.37 The basic considerations in planning irrigation schemes have been the cropping pattern, the intensity of irrigation and the duty of water which connotes the relation between the area irrigated and the quantity of water required to irrigate it. But once the project is constructed there is hardly any enforcement of cropping pattern or irrigation intensities. These emerge from the farmer's choice of crops determined by his own requirements and the profit he can make, and circumscribed by the available irrigation supplies. Some restrictions on growing water intensive crops like sugarcane are, however, imposed in Maharashtra through block system of irrigation and less successfully on rice in South India through localisation. Restrictions become necessary where waterlogging and salinity are apprehended or for better use of irrigation supplies. In areas with paucity of water resources it is inadvisable to grow water intensive crops like rice. For example, in Haryana with overall shortage of water for irrigation, the increasing trend to grow rice is not right and needs to be checked, as with the same quantity of water a much larger area can be brought under other foodgrains thereby benefiting a large number of cultivators. Some change in the pattern of irrigated crops is warranted in several other States also. For enforcing these, the State Governments should assume the necessary powers.

15.6.38 Irrigation channels are designed on the basis of these concepts of cropping pattern, intensities and duties although different States use different methods and empirical norms. For example in Haryana, channel capacities are generally based on a water allowance at outlets of 0.20 cusec per 100 hectares (2.75 cusecs per 1,000 acres) of culturable commanded area. Punjab and Rajasthan follow a

similar procedure. In Uttar Pradesh, the discharge at the distributory head is worked out by dividing the irrigable area by 96 for *rabi* and a smaller factor for rice. In Andhra Pradesh, Karnataka and Tamil Nadu, duties for various crops are adopted on the basis of past experience.

15.6.39 The above methods of designing irrigation channels are somewhat outmoded in the context of advanced technology in agriculture and irrigation practices and require sophistication. It has to be appreciated that neither the value nor the requirement of irrigation is uniform during the growth period of a crop. For rice the water requirement for puddling before transplantation is substantially higher than in subsequent stages and for good yield the transplantation has to be completed in a period of about four to six weeks. For wheat, 'kor' watering, which is needed three weeks after sowing at crown root initiation stage, is crucial and this should be completed in a period of about six weeks. In concentrated sugarcane areas, the crop requires irrigation at two to three week's interval. This requirement is maximum in the months of May and June when the rate of evapotranspiration is the highest. In cotton area there has to be sufficient supply to enable the crop to be sown in a reasonably short period of about four weeks. Thus, the channel capacities have to be such as would meet the maximum water requirement of the dominant crop at any stage along with irrigation requirement of other crops that may be on the ground. The actual irrigation requirement in an area depends upon several factors, such as the type of soil, climate, contribution from effective rainfall, if any, crop type and its duration, etc. These vary from project to project. Therefore, a uniform norm for channel design in a State cannot be a satisfactory basis. It is recommended that in future, irrigation channels should be designed keeping in view the considerations discussed above. The Agriculture Department should squarely take the responsibility of indicating the requirement of water during different periods of the crops to be irrigated keeping in view the limitation of supplies. If necessary, experiments should be undertaken by that Department to fill gaps in the required information. In the process of designing, it may be discovered that due to an overlap in crops in the field for a short period it requires an unduly large channel capacity to meet the irrigation requirement during that period. Such a channel would be both uneconomic in cost and unsatisfactory in operation. The difficulty can be overcome to a large extent by adopting a cropping pattern or crop varieties which would eliminate the overlap.

Operation of Irrigation System

15.6.40 The operation of an irrigation system is governed mainly by the demands of the predominant crop. Wheat and rice together account for more than 60 per cent of the gross irrigated area in the country. In the wheat producing States like Punjab, Haryana and Uttar Pradesh, more than 40 per cent of the irrigated area is under wheat. In the major rice producing States of Bihar, Tamil Nadu, Andhra Pradesh and West Bengal, the irrigated rice area in 1970-71, was 67 per cent, 71 per cent, 79 per cent and 90 per cent of the gross irrigated area respectively. In Maharashtra, Uttar Pradesh and parts of Bihar, there are concentrated areas of sugarcane crop. Similarly, in various parts of the country, there are concentrated areas of several other crops. Apart from the basic water requirement of each crop, the effective rainfall, and the texture and depth of soil have a bearing on the depth and frequency of irrigation. The operation of irrigation channels has thus to be fashioned to cater to the requirements of water in each case.

15.6.41 Irrigation schemes in the country are of two types, namely, diversion schemes which draw their supply from the run-of-the-river, and storage schemes where the irrigation channels get their supply from a reservoir. On diversion or run-of-the-river schemes, the supply of water in non-rainy season is limited by the river flows which vary from year to year. On these systems, any additional requirement in a particular period of crop growth can be met only from a supplemental source like groundwater. But knowing the pattern of water availability in the irrigation channels, better results can be secured by choosing crops and varieties whose water requirements correspond more closely to the pattern of supply. The Agriculture Department should provide guidance to the farmers in this respect, after ascertaining the pattern of availability of water from the Irrigation Department.

15.6.42 An irrigation system which receives its supply from a reservoir does not suffer from the constraint of limited supply during periods of keen demand as a run-of-the-river scheme does. It, therefore, lends itself to better regulation. It, however, must have adequate control structures on the channels for the purpose. Some of the older systems with rice as the main crop are deficient in this respect. On some of them when the canals are opened, all the distributaries and minors run simultaneously and during periods of slack demand a great deal of water is wasted. These canal systems should have proper regulators as in North India so that any channel could be closed when so required and channels run on a roster during periods of slack demand. It is to be mentioned that even in rice cultivation which

usually makes liberal use of water, water economy is possible and, in fact, beneficial. The yield of rice improves if the field is kept drained of water for 4 to 8 days after tillering and flowering stages, which correspond to 40 to 45 days and 75 to 80 days after transplantation respectively.

15.6.43 The importance of timely supply of irrigation water cannot be overemphasised. If the sowing of wheat is delayed beyond its proper period, the yield drops. In the case of high yielding varieties, the reduction may be about three quintals per hectare for the first three weeks of delay and a similar amount for each week's further delay. Likewise, if transplantation of rice is delayed by a month, a heavy drop in the yield of even up to 50 per cent may take place. Yields get considerably reduced if water is not supplied during the crucial stages of plant growth, such as emergence, seedling, tillering, pre-flowering, flowering and grain formation. The scheduling of irrigation supplies should aim at meeting these requirements on time. If these cannot be met in full, the running of channels should conform to the more crucial stages of growth of the predominant crop. For instance, for wheat if only three irrigations can be given, the choice would be crown root initiation, jointing and milk stages, and for two irrigations, only the first two.

15.6.44 Cultivators need premonsoon supply of water for raising rice nurseries for transplanting seedlings when rains come. On irrigation projects these nurseries are generally scattered all over the commanded area. Supplying canal water to these scattered patches of land is quite wasteful. But if canals are not run to supply water to these early nurseries, their raising is delayed till the monsoon sets in. This delays the transplanting operation and yields are affected. If nurseries are raised in compact blocks, preferably in the head reaches of minors on a commercial scale either by Government or by cooperative societies, it can ensure economy in the use of water for the nurseries as only the portions of channels serving these need be run. Alternatively, the nurseries can be raised with the use of groundwater if that be available. Such nurseries provide better control on the quality of seedlings and on the application of fertilisers and pesticides to them. These also facilitate regulated sowing of seeds to suit the subsequent transplanting operation. It has been established that in the case of high yielding varieties of rice the seedlings have to be of an exact age at the time of transplantation. Regulated nurseries can provide these. It may be mentioned that it is not necessary for nurseries to be close to the fields where rice is to be planted. Rice seedlings can stand a couple of days of transport and handling without injury. The arrangement of having compact rice nurseries should prove commercially successful. It would leave farmers free to attend to other

preparatory operations. This arrangement is recommended for adoption.

15.6.45 In diversion schemes from rivers in delta areas where rice is the main crop, the transplantation operation gets delayed if the monsoon is late or weak. This results in reduced yields from season-bound strains. The situation can be improved on rivers where storage reservoirs exist by having a standing arrangement for release of some water from the reservoir for timely raising of rice nurseries whenever the onset of monsoon is delayed. This may require some carryover in reservoirs.

15.6.46 In an irrigation system fed from a reservoir it becomes known with reasonable accuracy at the end of the rainy season as to the quantity of water that would be available for irrigation during the subsequent period. Based on this information it should be possible to draw up a plan, in consultation with the Agriculture Department, for the best use of this water and to determine the area under various crops for which water could be made available. A suitable schedule of running channels could then be drawn up. The information regarding the extent of area under the more important crops for which water would be available, and the tentative schedule of running channels should be widely made known to the farmers of the area, so that they may plan their cropping and connected operations accordingly. The schedule of channel operation should be modified from time to time as the season advances to suit actual requirements. Every time a change is made, the farmers should be advised of it as much in advance as feasible. On run-of-the river irrigation systems a precise schedule of canal regulation is not possible owing to uncertainty of river discharges. But even here a broad idea can be formed from a study of the prevailing meteorological conditions whether the supplies expected during the season would be more or less than normal. This information would be very useful to the farmers. In some States, there is already an arrangement for keeping the farmers informed about these matters.

7 PERSPECTIVE OF IRRIGATION DEVELOPMENT

15.7.1 We have earlier discussed the water resources that are expected to be available for agriculture on their near full development by the year 2025 A.D. These have been estimated to be of the order of 77 Mham. By that time the gross sown area in the country is anticipated to rise to 210 Mha from the 165 Mha sown in 1970-71. In order to make the optimum use of the available water resources,

certain policies will need to be observed. Briefly, these are :

(i) making the maximum use of rainfall for raising crops, utilising irrigation for making up deficiencies ;
(ii) adoption of the most suitable cropping pattern from consideration of soil, climate and availability of irrigation supplies ;
(iii) making the most efficient use of irrigation supplies by minimising losses in conveyance by lining and adopting scientific method of irrigation on properly prepared fields ;
(iv) deployment of irrigation supplies for maximum overall production and not necessarily maximum yields ;
(v) reuse of water to the extent feasible ; and
(vi) conjunctive use of surface water and groundwater.

It is estimated that with the observance of the above guidelines, it should be possible to ultimately irrigate about 110 Mha, that is, 52 per cent of the gross sown area of 210 Mha.

15.7.2 There is a wide disparity in the availability of water resources in the different States. The percentage of gross sown area that can be ultimately irrigated ranges between 17 per cent in Himachal Pradesh and 85 per cent in Punjab. On the basis of this percentage, the States can be classified into four groups as under :

Group I	—	less than 35 per cent Himachal Pradesh, Meghalaya, Maharashtra, Rajasthan, Madhya Pradesh, Gujarat.
Group II	—	between 35 and 50 per cent Tripura, Karnataka, Tamil Nadu, Nagaland and Union Territories.
Group III	—	between 50 and 65 per cent Andhra Pradesh, Manipur, Orissa, West Bengal and Haryana.
Group IV	—	65 per cent and above Assam, Jammu & Kashmir, Kerala, Bihar, Punjab and Uttar Pradesh.

States in Group IV and to a lesser extent those in Group III have a potential for good production. States in Group I and to a smaller extent those in Group II have less protection from irrigation and would, therefore, continue to be exposed to the vagaries of weather. In these States, there would be greater need for protective irrigation, though the need would vary from State to State and in different parts of a State. Some relief in the drought prone areas is possible by bringing in water from other basins which are better endowed with water resources. It may, however, be pointed out that because of physical and economic constraints, the relief through such transfers, though worthwhile, would be relatively small.

15.7.3 Statewise figures of the area sown and those of area irrigated in 1970-71 are now available. These along with the projections

for the years 2000 and 2025 are given in Statements in Appendices 15.2 and 15.3. As a number of factors are involved in increasing the cropped and irrigated areas, it has to be recognised that the projections cannot be precise. But they do give a broad perspective of what might be expected in each State.

15.7.4 It has been earlier shown that the ultimate irrigation potential in the country is of the order of 110 Mha, of which 70 Mha would be from surface water and 40 Mha from groundwater. At the commencement of the First Plan in 1950-51, the gross irrigated area in the country was 23 Mha, of which 16 Mha was from surface water and 7 Mha from groundwater. By the beginning of the Fourth Plan in 1968-69, the gross irrigated area had risen to 35 Mha, giving an average annual increase of 0.67 Mha over this period of 18 years. At the end of the Fourth Plan in 1973-74, the gross irrigated area is estimated to have risen to 42 Mha, 26 Mha from surface water and 16 Mha from groundwater. Thus, during this period of five years, the pace of development has been faster, being 1.4 Mha per annum on the average. A further step up in the pace can be reasonably expected. Taking various factors into consideration, it is envisaged that future utilisation of irrigation may be as in Table 15.6.

TABLE 15.6

Perspective of Gross Irrigated Area

(million hectares)

Year	Surface water	Ground-water	Total
1950-51	16	7	23
1968-69	23	12	35
1973-74	26	16	42
1980	31	20	51
1985	36	25	61
1990	41	28	69
1995	46	31	77
2000	51	33	84
2005	56	35	91
2010	61	37	98
2015	65	38	103
2020	68	39	107
2025	70	40	110

15.7.5 The development of groundwater has been quicker than that of surface water and it should be possible to develop most of it by the year 2000. Beyond that period, the pace of its development

would be determined by the development of the surface water resources, as further increase in the groundwater resource would depend on increased infiltration from new irrigation projects and other special measures that might be taken to augment it. As groundwater on being tapped gets quickly utilised, the present emphasis on its speedy development should be continued in future, ensuring at the same time replacement of wells that may go out of use.

15.7.6 The scope for future development of surface water is almost twice that of groundwater. Therefore, there should be no slackening of effort to develop surface water while doing more for exploiting groundwater. This is particularly so as major irrigation schemes have long gestation period and unless these are taken up early enough the desired pace of development cannot be attained. In order to properly phase the programme of surface water development there should be a large number of fully investigated schemes ready to choose from. Also, once a scheme is taken up for implementation, the funds required to complete it in the shortest time as determined by technical considerations including availability of scarce materials, should be fully provided. From this it follows that only as many projects should be taken up at a time as can be implemented at their optimum pace. These points have been made on a number of occasions by various authorities in the past but in spite of that they have not always been observed. We consider them important enough to reiterate here.

15.7.7 In many States, irrigation resources that have yet to be harnessed are large. Table 15.7 gives Statewise figures of the gross area which might be irrigated by 2025, that irrigated in 1970-71 and the balance that remained to be brought under irrigation.

TABLE 15.7*

Scope for Development of Irrigation

(million hectares)

State	2025	1970-71	Balance	Surface water	Groundwater
1	2	3	4	5	6
Uttar Pradesh	24.0	8.4	15.6	7.4	8.2
Bihar	13.1	2.7	10.4	7.0	3.4
Madhya Pradesh . . .	9.1	1.5	7.6	5.2	2.4
Andhra Pradesh . . .	10.2	4.2	6.0	4.5	1.5
Orissa	6.7	1.6	5.1	3.7	1.4
Maharashtra	6.5	1.7	4.8	3.9	0.9
Karnataka	5.9	1.4	4.5	3.2	1.3
West Bengal	5.5	1.5	4.0	1.5	2.5
Gujarat	5.0	1.3	3.7	3.2	0.5
Rajasthan	4.8	2.5	2.3	1.8	0.5

1	2	3	4	5	6
Kerala	2.6	0.6	2.0	1.7	0.3
Assam	2.5	0.6	1.9	1.2	0.7
Haryana	3.3	2.2	1.1	0.6	0.5
Punjab	5.0	4.2	0.8	0.2	0.6
Tamil Nadu	4.0	3.4	0.6	0.1	0.5
Jammu & Kashmir . . .	0.7	0.3	0.4	0.2	0.2
All other States and Union Territories	1.1	0.4	0.7	0.6	0.1
TOTAL	110.0	38.5	71.5	46.0	25.5

* The figures for 1970-71 are taken from Indian Agriculture in Brief, Thirteenth Edition published by the Ministry of Agriculture and Irrigation. Other figures have been derived from the data given in the Report of the Irrigation Commission — 1972, Draft Fifth Five Year Plan and the information published or supplied by the States and Central Ministries.

With full development of irrigation in some of the States ahead of the others, the tempo of development in the latter would need to be stepped up in order to keep up the pace of development in the country. The latter States may at that stage require relatively larger outlays for the purpose, and this would require consideration at that stage.

8 CROPPING IN IRRIGATED AREAS

Water Requirement and Choice of Crops

15.8.1 Crops require water for their consumptive use, *i.e.*, for transpiration, evaporation from adjacent soil and for the building of plant tissues. The evapotranspiration is governed, primarily, by meteorological factors, such as sunshine, temperature, humidity and wind velocity. When a field is fully covered with vegetation, the transpiration is very nearly equal to panevaporation there. The ability of a plant to draw water from soil depends on its root system as also on the nature of the soil. Clayey soils have a greater waterholding capacity but higher wilting coefficient than sandy soils. In consequence, a crop would wilt in relatively higher moisture in clayey soil than in sandy soil. The total quantity of water which a crop would require for evapotranspiration would be independent of the nature of soil, but in sandy soil more frequent and shallower irrigation would be necessary than in the case of clayey soil. Sufficient meteorological data are available for the various parts of the country to enable a fair estimation to be made of the consumptive use of water by crops. These data, however, need to be compiled and presented in a more readily usable form.

15.8.2 The irrigation requirement of a crop in the field is the quantity of water which needs to be applied to it for its successful growth, exclusive of any contribution from effective* rainfall and capillary water. It also includes unavoidable losses in the application of water in the field, both as surface runoff and deep percolation. To these have to be added transit losses to determine the quantity of water which has to be made available from the source. Actually, the losses, both in the application and conveyance of water, are considerably higher than they need be. This offers scope for improvement in the utilisation of irrigation supplies to cover larger cropped area.

15.8.3 The farmer's choice of an irrigated crop is governed primarily by consideration of the net income which he can derive from it. But there are certain technological and economic considerations which need to be borne in mind in the long term interest of both the farmer and the nation. The more important of these are discussed in the paragraphs that follow.

15.8.4 Rice which is grown in about 40 per cent of the irrigated area under all crops is the largest consumer of irrigation water, accounting for 50 per cent of the total irrigation supply at present. Next comes wheat followed by other cereals, and these take 15 and 12 per cent of the supply respectively. Amongst cereals rice has the lowest productivity per unit of water as is evident from the table below.

TABLE 15.8

Productivity of Cereals per Unit of Water[1]

Crop (new strains)	Water requirement in a typical tract (mm)	Yield (kg/ha)	Productivity per mm of water (kg/ha)
rice	1,200	4,500	3.7
sorghum	500	4,500	9.0
bajra	500	4,500	8.0
maize	625	5,000	8.0
wheat	400	5,000	12.5

1 1969, Dastane, N. G. (1972). New Concept, Practices, and Techniques in the Field of Water Use and Management.. Proc. Symposium on Soil and Water Management, held at Hissar, ICAR, Spl. publication: p. 109-133.

The main rice crop is, however, grown in the rainy season and irrigation supplies are needed to make up the water requirement left unmet by rainfall. Rice crop grown in non-rainy season or low rainfall areas consumes disproportionately more water than the production it gives. Under these water paucity conditions, therefore, rice should be grown only if the available irrigation supplies cannot be put to better use for other crops.

* Effective rainfall in a crop season is that portion of the rainfall which is available for meeting the evapotranspiration requirement of crops. It excludes the portion which is lost as runoff or deep percolation below root zone or as instant evaporation.

15.8.5 For growing a crop water is required for land preparation where presowing soil moisture is inadequate, for evapotranspiration, plant structure and meeting the percolation and seepage losses during the period of its growth. The rate of evapotranspiration is primarily governed by meteorological factors and for a given location is independent of crop species in a field with full crop cover. It follows, therefore, that the longer the duration of a crop the greater is the evapotranspiration requirement. As regards the rate of percolation and seepage losses, it is highest in the case of rice as water has to be kept standing in the field for most part of its growth period. The daily water requirement of rice thus depends upon climate and the permeability of the soil, and its total requirement on the length of its growth period.

15.8.6 Recent experiments on water requirements of rice on loamy soils showed that out of 1,680 mm of water used in the field, 1,200 mm was lost through percolation and only 480 mm was actually utilised by the crop. The amount of water applied to rice fields on most irrigation systems in the country is considerably more than the actual requirement and is sometimes as high as 2,500 mm. The greater part of the irrigation water is thus lost through percolation and other means. In heavy clay soils, the wet season water requirement of rice for peak yield can be as low as 650 mm. In general, where the permeability of soil is more than 5 mm per day, from the point of view of water use, it is unfavourable to grow rice.

15.8.7 In the southern States, wherever the heavier black cotton soil is located in the valleys and the lighter red soil higher up, it would be a good arrangement to confine growing rice to the valleys reserving the lighter soils for light irrigated crops, as otherwise, apart from consuming more water due to greater percolation losses, the percolated water would make the heavy soil lower down soggy rendering it unfit for growing any other crop than rice. This has happened on some existing projects, such as Lower Bhawani, Tungabhadra, Hirakud, etc.

15.8.8 We recommend, therefore, that rice should be grown preferably where there is good support from rainfall on soils which have a permeability less than 5 mm per day, and lower down in valleys where generally there is heavy soil. Further, rice should be grown in non-rainy season or low rainfall areas only if the available irrigation supplies cannot be put to more economic use for other crops.

15.8.9 In low rainfall areas, it is important that there should be at least one assured crop to sustain the farmer. As water resources in such areas are scanty, irrigation supplies have to be put to the most economical use in order to extend the benefit of irrigation to as large a number of people as possible. Under these conditions where

the interval between successive waterings is prolonged, deep-rooted crops do better if there is good depth of soil as they can tolerate longer dry spells than shallow rooted ones.

Amongst the different groups, the species in increasing order of moisture stress tolerance are :—

cereals	*kharif* :	maize, pearl millet, sorghum, crowfoot millet.
	rabi :	wheat, oats, barley.
pulses	*kharif* :	cowpeas, black gram, green gram, soyabean, pigeon pea, cluster bean.
	rabi :	lentil, peas, gram.
oilseeds	*kharif* :	groundnut, sesamum, castor.
	rabi :	linseed, sunflower, safflower, mustard.

15.8.10 In water paucity areas, the duration of an irrigated crop is important, as the source of irrigation may not admit of the number of waterings required by a long duration crop. Table 15.9 gives, illustratively, the crops with their duration which fit in different ranges of total utilisable water available during *kharif* and *rabi.*

TABLE 15.9

Crops for Different Ranges of Total Water Availability and their Duration

mm	*Kharif*	Days	*Rabi*	Days
250—400 .	pearl millet	85—100	barley	120—140
	sorghum and maize fodder	60—90	gram	120—140
	greengram	60—90	peas	90—130
	blackgram	80—105	safflower	140—180
	castor	180—240	linseed	140—160
	sesamum	100—120	mustard	120—150
400—600 .	sorghum	90—120	wheat	120—150
	groundnut	100—150	barley	120—140
	soyabean	110—130	sorghum	90—120
	tobacco	120—150	coriander	120—150
	cotton	180—210		
	vegetables	60—90		
600—1000 .	maize	110—130	berseem	210—240
	cotton	180—210	potato	90—120
	vegetables	90—120	onion	140—160

From table 15.9 it is evident that even in low rainfall areas, the farmer has a number of crops to choose from.

15.8.11 The choice of irrigated crops in alkali and saline soils is somewhat limited. These soils, particularly when sodic, have low permeability. During *kharif,* therefore, rice is a suitable crop for such areas. Even amongst the rice varieties some do better. Cotton after

the seedling stage is tolerant to salinity but is very sensitive to flooding and high alkali conditions. Legumes, except dhaincha (*Sesbania aculeata*), are very sensitive to alkali and salinity conditions and are, therefore, unsuitable for growing in these soils. In *rabi*, wheat, barley, sugarbeet, berseem, sanji, raya (*Barssica juncea*) can be grown after a *kharif* rice crop. Amongst the oilseeds, safflower appears to be sensitive to alkaline conditions but can be grown on saline soils.

Frequency, Timing and Depth of Watering

15.8.12 Crops draw their water requirement from the moisture in the soil. The total storage of moisture in the soil depends upon its depth and waterholding capacity. The finer the texture of soil the greater is its waterholding capacity. Within limits, the depth and texture of soil thus govern the depth and interval of irrigation and in consequence the scheduling of irrigation supplies. With evapotranspiration the soil moisture gradually gets depleted till it becomes so low that the crop is unable to draw a sufficient amount of it and wilts. Irrigation is needed long before that stage as yield is affected much earlier than wilting. It has to be borne in mind that once a crop has had a setback due to insufficiency of soil moisture, the damage done cannot be fully repaired by any subsequent copious watering. The interval at which irrigation should be done depends primarily upon the evaporative demand of the climate. The quicker the water transpires from a cropped field the shorter is the interval required for irrigation. In North India, the mean values of evapotranspiration in *kharif, rabi* and hot weather are 4.5, 3.0 and 6.0 mm per day respectively, while in South India these are 4.5, 3.5 and 5.5 mm per day. The frequency of irrigation is also influenced by its depth. Irrigation with smaller depth of watering has to be more frequent in order to meet the water requirement of a crop. Normally, the depth of watering would range between 5 and 10 cm.

15.8.13 The depth of irrigation required by a crop depends upon the soil moisture deficit in the effective root zone of the crop. Thus, a knowledge of the waterholding properties of soils and the rooting of crops is essential to decide the quantity of water to be applied. In addition, application losses have to be allowed for. These losses depend upon the degree of land levelling, soil texture, stream size and the mode of irrigation. Insufficient depth of irrigation can lead to the problem of soil salinity.

15.8.14 In water paucity areas in irrigation system may cater for fewer waterings than required for maximum yields. This may be so in order to extend the benefit of irrigation to a large number of

farmers. Under these conditions it becomes very important that irrigation is done during the crucial stages of crop growth if serious reduction in yield is to be avoided. In experiments conducted by the Indian Agricultural Research Institute, New Delhi with wheat (*Sonora* 64) a single irrigation 25 days after sowing raised the yield to three times that of an unirrigated crop. With three waterings at the most appropriate stages, the yield was 3.8 times; with four waterings 4.5 times and five waterings 5.1 times. These results show that in water paucity areas with a fewer than the optimum number of waterings on a larger area and appropriate timing of irrigation, a greater overall production can be secured.

Irrigation in Relation to Agroclimatic Zones

15.8.15 Temperature, type of soil and the extent and distribution of rainfall together go to determine the most suitable crops that can be grown in an area. For example, wheat is best sown in the cool climate above latitude 20°. Similarly, while wheat does well in loam and sandy loam, rice requires clayey soils which have low permeability. But apart from consideration of temperature and soil type, under rainfed conditions it is the extent and distribution of rainfall which is the main factor that determines the crops suitable for an area. Given irrigation supplies even rice can be grown in an arid area but that would be unnatural and not the best use of available water. If the water resources which are available for irrigation in various parts of the country are to be put to the maximum productive use, then it should be the rainfall that should meet the basic water requirement of the crop grown, irrigation water being used only to make up the deficiencies in rainfall. In low rainfall areas, however, the supplemental irrigation requirement would be relatively large. For each region or area the crops in an irrigated command are best chosen from amongst those which are natural to the area under rainfed conditions and their yields increased and assured with irrigation supplies. It is in this context that consideration of agroclimatic zones assumes importance in planning an irrigation project.

15.8.16 On the basis of distribution of monthly rainfall in a year, we have delineated the country into various rainfall pattern zones. This has been done by analysing tehsilwise monthly rainfall data for periods of 50 years or more as recorded by the Indian Meteorological Department. Details of the various delineated zones are given in Chapter 14 on Rainfall and Cropping Patterns.

Cropping Pattern

15.8.17 The patterns of cropping in rainfed areas are dictated largely by climate, extent and distribution of rainfall and the nature

largely by climate, extent and distribution of rainfall and the nature of soil. They cannot be altered at will and, therefore, restrict the choice of crops which can be grown in an area under rainfed conditions.

15.8.18 We have dealt with balanced cropping in Chapter 14 on Rainfall and Cropping Pattern. Here we mention the conditions of water availability under which the more important crops would do well. Rice requires a rainfall of more than 30 cm per month for at least three consecutive months. Failing that, it has to be irrigated for good yield. Wheat is a *rabi* crop. During that period, rainfall and in consequence natural soil moisture is generally insufficient and irrigation becomes necessary for a good crop. Sugarcane requires water all the year round and, therefore, has to be irrigated. In areas with rainfall higher than 30 cm per month for two months, maize can give good yield even without irrigation but with adequate drainage. With lower rainfall, it has to be irrigated for a good yield. Bajra and jowar require less water than maize and can do well in areas with rainfall of 10 to 20 cm per month for more than a month. If rainfall is 10 to 20 cm per month in only one month, they too would require irrigation. Cotton is best grown in irrigated areas. Fodder and vegetables require irrigation during non-rainy months or where rainfall is inadequate. The important point to bear in mind is that irrigation has to help in making the best use of rain water in any season and crops should be planned to take the fullest advantage of available rain water. In irrigated areas there is some flexibility in the choice of crops and often one can do more of one crop and less of another within the given parameter of climate, soils type and rainfall. It is thus possible to adjust the cropping pattern on irrigation projects to meet the food and fodder requirements in a balanced manner in conjunction with the production of various crops in unirrigated areas.

15.8.19 In 1970-71, the gross area sown and the irrigated were 165 Mha and 38.5 Mha respectively. By the turn of the century, these are expected to rise to 200 Mha and 84 Mha, and further rise to 210 Mha and 110 Mha by 2025 A.D. In Table 15.10 are given cropwise figures of area sown and area irrigated, these being actual for 1970-71 and projections for 2000 and 2025 A.D. for a balanced agricultural production.

15.8.20 There are certain imbalances in the area under various crops and these have to be gradually removed. Rice is at present grown in several areas at a time when there is inadequate rainfall to sustain it. Yield of unirrigated rice in these areas is poor. These areas are best changed over to other crops for better production. There is a great demand for more oilseeds in the country and area under these crops need to be increased substantially. Fodder is not

TABLE 15.10

Projections of Cropwise Area Sown and Irrigated

(million hectares)

Crop	1970-71		2000 A.D.		2025 A.D.	
	Area sown	Area irrigated	Area sown	Area irrigated	Area sown	Area irrigated
Rice	37.4	14.9	32.0	24.0	34.0	30.1
Wheat	18.2	9.8	17.5	14.9	18.0	17.3
Barley and oats	2.6	1.3	6.0	1.8	6.0	2.2
Millets	43.2	2.5	42.5	5.2	44.0	6.9
Pulses	23.1	2.0	25.0	5.4	26.0	7.0
Sugarcane and sugarbeet	2.6	1.9	5.5	5.5	6.0	6.0
Groundnut	7.5	0.6	9.0	1.9	9.0	2.6
Other oilseeds	6.2	0.4	16.5	3.2	16.0	4.0
Cotton	7.7	1.3	11.5	7.5	12.0	8.8
Jute and other fibres	1.2	0.1	1.5	1.0	1.6	1.3
Fodder	7.0	1.4	16.5	6.5	18.0	11·3
Vegetables* and related crops	3.1	1.2	8.3	4.2	10.0	7.4
Fruits*	1.2	0.4	4.0	1.2	4.2	2.2
Plantation* crops	2.2	0.4	2.8	1.0	3.0	1.6
Tobacco	0.4	0.1	0.6	0.4	0.6	0.4
Flowers and medicinal plants and miscellaneous crops	1.5	0.2	0.8	0.3	1.6	0.9
TOTAL	165.1	38.5	200.0	84.0	210.0	110.0

* As per classification given in Chapters 23 and 24 on Horticultural Crops and Plantation Crops.

being grown in sufficient quantity. During *kharif*, much of it is grown as a rainfed crop but it requires irrigation during *rabi* and *zaid* seasons. The area under fodder must be increased substantially if the cattle are to be fed properly and their breeds improved. The area under cotton needs to be stepped up to meet the growing requirement of cloth. A substantial area under this crop would require irrigation.

15.8.21 The cropping patterns for various rainfall zones in the country have been discussed in detail in Chapter 14 on Rainfall and Cropping Patterns. A Statewise breakup of the irrigated area under the principal crops for the years 1970-71, 2000 and 2025 is given in Appendix 15.4. It is to be noticed that some reduction in the area under rice has been considered necessary in Andhra Pradesh and Tamil Nadu by replacing it with another crop where the yields are poor or water is not utilised to the best advantage. The increasing requirement of rice has to be met by bringing more of rice area under irrigation in regions where rainfall is fairly high for at least two

months needing supporting irrigation for only a month or so. It is visualised that in course of time particularly the entire wheat and sugarcane crops would be grown under irrigated conditions. An all-round increase in the yield of crops has to be secured with a complete package of inputs and technological improvements.

15.8.22. We now touch upon, Statewise, the more important shifts which are considered desirable in the prevailing cropping patterns in irrigated areas. The change can be gradual as more area is brought under irrigation. We have dealt with at some length the area and production of various crops in Chapters 21 to 25 on Foodgrains, Commercial, Horticultural, Plantation and Fodder Crops.

Andhra Pradesh : The main irrigated crop in this State is rice and accounts for 79 per cent of the irrigated cropped area. There is need to grow more of irrigated fodder, cotton, millets and oilseeds. These require less water than rice. Their proportion could be increased by a corresponding reduction in the proportion of the area under rice.

Assam : Rice is the main crop and should continue to be so, as rainfall conditions are favourable for this crop. However, more of fodder, vegetables, fruit and plantation should be raised than at present.

Bihar : Rice and wheat are the predominant irrigated crops in the State and would continue to be so. They cover 67 per cent and 26 per cent of the irrigated area respectively. The area under vegetables, fruits, sugarcane, pulses and other crops is insignificant and needs to be substantially increased. Practically no irrigated fodder is grown in the State which has a large number of ill-fed cattle. For improving their condition, there has to be sufficient fodder and this should be an important crop in canal commands.

Gujarat : Cotton and wheat are the main irrigated crops at present, each covering about 23 per cent of the cropped area. The proportion of area under fodder and oilseeds should be stepped up. Banana is doing very well in the State and can be encouraged.

Haryana : In this State, wheat constitutes 41 per cent of the irrigated cropped area. As irrigation develops, more of cotton, oilseeds, pulses, and vegetables should be raised without actually decreasing the area under wheat. Both rice and sugarcane are water intensive crops. The area under these crops should be therefore restricted in view of the paucity of water resources in the State.

Jammu and Kashmir : Rice is the major crop in the State and covers 70 per cent of the irrigated cropped area. It should continue to be the main crop. However, more of fodder is necessary in the interest of development of animal husbandry which is a major plank in the development programme of the State.

Karnataka : Rice and millets are the main irrigated crops in the State and cover 51 and 16 per cent of the irrigated cropped area. In order to spread the benefit of irrigation to larger area, the proportion of the water intensive rice crop need to be reduced and millets, pulses and oilseeds, which require less water should be increased. The black soils in the State are very suitable for cotton and therefore, its proportion should be substantially increased. Fodder, sugarcane, vegetables, fruit and plantation are the other crops which should be increased.

Kerala : Rice is the main crop in the State and occupies 83 per cent of the irrigated area. The rest of the irrigated area is under vegetables, fruit, spices, condiments and plantation crops. From the national point of view, the irrigated area under crops other than rice would need to be increased very appreciably, but on full development the area under rice need not necessarily be below its present level.

Madhya Pradesh : Rice and wheat account for 40 and 30 per cent respectively of the irrigated cropped area. Wheat should, however, be mostly confined to the cooler northern part of the State for good yield. The percentage area under irrigated cotton, fodder and sugarcane should be increased.

Maharashtra : The main irrigated crops at present are millets 21 per cent, rice 18 per cent, wheat 15 per cent, sugarcane 13 per cent, cotton 5 per cent, vegetables, fruit and other crops 18 per cent. Millets should continue to be the main crop as the soil and climate are suitable for them, but the proportion of wheat should be reduced as the temperature there is somewhat high for good yield. Rice should be confined mostly to the western coast areas. Cotton, oilseeds, pulses and fodder need to be stepped up considerably.

Orissa : Rice occupies 87 per cent of the irrigated area. There is need to do more of fodder, vegetables and fruit which would bring down the percentage of rice in the future irrigated area. Cotton and oilseeds should be encouraged.

Punjab : Wheat is the most important crop in the State and occupies 45 per cent of the irrigated cropped area. Other important crops are fodder, millets, rice and cotton. For a more balanced cropping pattern, millets should be reduced and cotton, vegetables and fruit increased. Rice and sugarcane being water intensive should not be increased from the present level. Sugarbeet should be encouraged.

Rajasthan : In the irrigated areas, wheat is the major crop at present and covers 40 per cent of the irrigated cropped area. In this State, agricultural development should be based on mixed farming, with animal husbandry playing a key role. There is, therefore, need to increase fodder crops. Millets, pulses and oilseeds should also be increased. These are low water consuming crops. Sugarcane and rice being water

intensive should not be encouraged in the State.

Tamil Nadu : About 71 per cent of the irrigated cropped area is under rice. Not all of this is grown under good soil or rainfall conditions. Hardly any irrigated fodder is grown in the State. The proportion of area under cotton for which soils are suitable is very low. Therefore, the area under irrigated fodder and cotton should be substantially increased by reducing that under rice.

Uttar Pradesh : At present of the irrigated cropped area, 47 per cent is under wheat, 12 per cent under pulses, 11 per cent under sugarcane, 10 per cent under rice and 9 per cent under barley. Other crops cover a small area. For a proper use of the water resources in the State, a change in the cropping pattern would be necessary. Rice should be stepped up to utilise the abundant surface water flows during the monsoon season. That would also increase the groundwater recharge which would be useful in the *rabi* period. Although on full development, there will be more irrigated wheat area than at present, its proportion would decrease in favour of other crops. There is need to increase irrigated fodder in order to improve the cattle wealth in the State. Area under vegetables and fruit should be increased, as also that under cotton and oilseeds. Although the actual area under irrigated sugarcane may ultimately increase, its proportion in the total irrigated area should be reduced. The yield of sugarcane in the State is not high and its water requirement during *rabi* overlaps that for wheat, barley, fodder, etc. to their detriment.

West Bengal : There is a good potential for the development of groundwater in this State. Groundwater is more suitable for less water intensive crops like wheat, fodder, vegetables, fruit etc., than for rice. With more emphasis on the less water intensive crops, the percentage of rice on further development of irrigation may decrease substantially from the present 90 per cent. Area under wheat should be increased substantially. Already this crop is catching on. Area under irrigated fodder is negligible at present and should be increased to improve the cattle wealth. Also, cotton and oilseeds should be encouraged.

Other States : In the States of Manipur, Maghalaya, Nagaland and Tripura, rice would continue to be the main crop and development of irrigation would mainly cater for this crop. In Himachal Pradesh, however, wheat would be equally important.

9 DRAINAGE

15.9.1 Crops suffer damage when there is excess water in the soil in the root zone, as it hampers aeration. In soils which are too wet,

roots tend to spread out near the surface and remain shallow. This reduces the volume of soil from which the plant may draw nutrients. It also makes the plant more vulnerable to subsequent drought conditions as the shallow roots may fail to avail of the sustaining moisture that may be there lower down. The susceptibility to damage due to excessive soil moisture differs in different crops as also in the stages of their growth.

15.9.2 In all irrigation systems it is important to provide adequate drainage. Water percolating from irrigation channels and irrigated fields can raise the groundwater table and cause waterlogging and salt accumulation. We have dealt with the problems of salinity and alkalinity in irrigated areas in Chapter 17 on Land Reclamation and Development. For want of proper drainage, large areas on some of the old irrigation systems in arid and semi-arid areas became waterlogged and salt infested. Subsequent remedial measures in the shape of extensive drainage works and shallow tubewells to depress the groundwater table have not fully restored the damaged lands to their original health. In recent years, there has been increasing awareness of this problem and it has been laid down that in all new irrigation schemes, there must be adequate provision for drainage. It is, however, noticed that these provisions are not always adequate and that the drainage is not planned comprehensively. Several project estimates have contained only a token or lump sum provision, which later on has been found to be completely inadequate. We wish to emphasise that drainage is an important item in an irrigation project and its investigation and estimation should be given the same amount of attention as is bestowed on irrigation channels and watercourses. Depending upon the terrain and nature of the soil, it can be a very sizeable item. But without it the project would be incomplete and will not bear full fruit.

15.9.3 To be effective, drainage system should extend to field drains. Field drains are required not only for crops requiring light irrigation but also for rice fields. It is important to remove unwanted water from rice fields, particularly during the stage of seed bed preparation and harvest. Even during the growth period of rice periodical drainage of water has been found beneficial. In recent drought years, it was experienced that short breaks in the supply of water to rice fields resulted in higher yields.

15.9.4 For the efficient functioning of drainage system in irrigated areas, the nallas lower down have to be kept clear of all obstructions. These natural waterways are apt to be encroached upon for illicit cultivation and blocked for lifting water for irrigation or catching fish. The responsibility for the proper maintenance of these should be placed squarely on a single department. In most States, this responsibility lies with the Irrigation Department. Irrigation Acts in some of the States

empower Government to construct and maintain field and other drains, and in most States to prohibit the creation of obstructions in notified streams and drains. The States may review the position in this regard and assume adequate powers, where these are deficient.

15.9.5 Not all crops suffer equally from root submergence for a period of time. The damage varies from crop to crop and the stage of growth. Even for the same crop, different varieties are susceptible to different degrees. While information is available in general terms regarding the relative susceptibility of various crops to root submergence, more precise and scientific data in quantitative terms are not available. It is recommended that research should specifically be carried out on this topic.

15.9.6 There are numerous ponds, large and small, called *'Chaurs'* or *'Hoars'* in the flat alluvial areas of Assam, West Bengal and North Bihar, where water keeps standing for most part of the year. Some of these can be drained and the reclaimed area brought under crops. But in a number of cases, the cost of drainage would be high. In some cases pumping would be involved. For instance, in the command area of Kosi Project the area under *'Chaurs'* is about 117,000 hectares. In the deeper portions water remains standing throughout the year. There has been a suggestion that water should be pumped out from the deeper portions which cannot be drained by gravity. The whole idea of draining these *'Chaurs'* dry is to put the land to economic use by raising crops there. But, there is an alternative use for them, namely, pisciculture. In the summer months when the *'Chaurs'* shrink and tend to dry they can be replenished with canal water to the extent necessary to maintain the fish. The canal water can be paid for as for irrigation. It may be pointed out that area for area a pond can give as much income, if not more, from pisciculture as crops. And fish can supply protein of superior quality in which foodgrains are deficient. It is suggested, therefore, that, in general, before any scheme of dewatering a *'Chaur'* is undertaken, the economics and feasibility of putting it under pisciculture should be carefully examined. In several cases a combined scheme of drainage and pisciculture may be found to be the best arrangement, the drainage providing relief to the peripheral areas from submergence. Also, tanks can be deepened and the earth used for raising marginal lands for cultivation.

15.9.7 In irrigated areas it is desirable to keep the average watertable well below the capillary range, say around 3 to 5 metres if not deeper. Apart from the risk of increasing soil salinity a high watertable is wasteful of groundwater resource as it contributes to unproductive evaporation. Also a low watertable provides more space for groundwater recharge during the rainy season and thus helps in increasing the groundwater resource.

10 MODERNISATION OF EXISTING IRRIGATION SYSTEMS

15.10.1 In recent years, the science and technology of agriculture has made revolutionary progress and given rise to new patterns of demand for inputs amongst which irrigation is an important one. These demands have to be met satisfactorily for optimum production. Many of the older irrigation systems in the country, and even some of the more recent ones, do not meet the requirements of modern agriculture adequately and call for modernisation. The Irrigation Commission (1972) has dealt with at some length the question of improvement of existing irrigation systems in order to increase their efficiency and usefulness. It has pointed out that in the run-of-the-river schemes, which derive their supply of water solely from diversion works on rivers, shortages are experienced during the low stage of river flows which occur in summer in the peninsular rivers and in winter in the Indo-Gangetic rivers. The earlier irrigation systems of North India were designed with low intensities and cultivators given a share of water proportionate to their holdings in the command area. They have naturally been applying water thinly to irrigate as much area as feasible. This mode of irrigation is not conducive to high yields, particularly from high yielding varieties. The Irrigation Commission has further pointed out that on many irrigation systems, the channel capacities are inadequate for meeting peak demands during crucial periods like transplanting of rice, *kor** irrigation of *rabi* crops, etc. Because of inadequate channel capacities, the period of irrigation during these crucial stages gets prolonged resulting in low yields. Tail reaches of canals suffer most from these inadequacies.

15.10.2 Apart from structural improvements of these projects such as remodelling of headworks where the existing ones are not functioning satisfactorily like the Tajewala and Okhla Weirs, excluding drainge from irrigation channels by providing separate drains as required on the Cauvery canal system, providing regulators and escapes for better control in the operation of canals, enlarging channel capacities where necessary, improvement of drainage in the command area, etc., the Irrigation Commission has recommended that inadequate supplies in the canals should be supplemented by providing storage backing where feasible, diverting surplus water from other basins and the use of groundwater. Also, the Commission has recommended a re-examination of the existing projects with a view to improving their efficiency and usefulness.

15.10.3 In the plans, programmes for development of irrigation have been mainly in the shape of new irrigation schemes. Some re-

*First watering after sowing

modelling or replacement of old and decrepit major engineering structures, like the Krishna Anicut in Andhra Pradesh and Sone Weir in Bihar has been done primarily to safeguard existing irrigation supplies. Also on certain canals, supplemental supplies have been provided through storage dams, transfer of water from another sub-basin, augmentation by tubewells or river pumping schemes. For example, in Uttar Pradesh the Ramganga storage reservoir will provide additional supplies to the Lower Ganga Canal, the Sarda Sahaik Project will convey waters of the Ghaghara to the lower portion of the Sarda Canal, and the Dalmau Pumping Scheme on the Ganga is providing water to the lower portion of the Sarda canal system. A few old channels have also been lined to save on transit losses. All these efforts at improvement of existing canal systems have been mainly in the field of engineering. None of these systems have been reviewed comprehensively for improvement in all aspects covering engineering structures for safety and better regulation, augmentation of supplies in the system where deficient, efficiency in conveyance of water to the field, scientific application of water to crops and adoption of cropping patterns which would confer the maximum benefit. Such reviews of the old and the earlier plan projects are called for in order to modernise them for better service to present-day agriculture.

15.10.4 These reviews should be carried out by officers of the same high level of competence as are required for formulating a new irrigation scheme. In fact, the review should be a *de novo* formulation of the scheme conditioned by the existing physical constraints. This would indeed be a task for a team of specialists in irrigation engineering, agronomy and soils. The association of an agricultural economist in these reviews would be desirable. The responsibility for the reviews has naturally to be that of the Irrigation Department, the Agriculture Department making other specialists available to form the team. There should be a forum to iron out differences of views and take decisions.

15.10.5 To start with the irrigation policy in respect of the project and preferably for the entire basin or sub-basin should be clearly laid down by Government. The various irrigation policies have been discussed by the Irrigation Commission (1972) in its Report. The choice would be for deployment of irrigation supplies for (a) maximum production per unit of area; or (b) maximum production per unit of water; or (c) maximum area served. The reviews may call for some experiments and observations. Alternative cropping patterns and varieties may have to be field-tested before adoption. Soil analysis may become necessary if adequate data on soils in the command area are not available. Observations may become necessary to determine percolation and seepage losses as also evapotranspiration losses during different seasons. These measures should be initiated early, so that a proper

review of projects is not inordinately delayed. These tasks would need to be assigned for completion according to a prescribed time-table.

15.10.6 Whenever a new project is formulated to make up the water deficiencies in an existing project or enlarge its scope, it is important that the existing project should be carefully reviewed in all aspects and the required changes planned with the preparation of the new scheme. In fact, there should be a comprehensive project formulation combining the old and the new project. The cropping pattern on the old project, under the changed conditions, should be carefully reviewed. Where channel capacities have to be increased to take supplemental supplies, it would be a suitable occasion to line the channels if not already done, as lining in itself will provide substantial increase in capacity apart from conferring other benefits.

15.10.7 In order to get an idea of the scope of improvement in the existing irrigation projects and to establish a methodology for such reviews, we requested a few States, in December 1971, to make a review of some selected medium sized storage projects where irrigation had more or less fully developed. Guidelines for the review were suggested covering engineering, water utilisation and agronomic aspects. The following five projects were reviewed:

(i) Badua Project (Bihar);
(ii) Ghod Project (Maharashtra);
(iii) Harsi Project (Madhya Pradesh);
(iv) Shetrunji Project (Gujarat); and
(v) Lower Bhawani Project (Tamil Nadu).

The Commission visited the first three projects in 1972 and discussed with the State authorities the results of the studies carried out by them. In view of the importance which we attached to such reviews, we submitted an Interim Report on the subject in February 1973, recommending provision of adequate funds for the purpose in the Fifth Plan then under preparation. Guidelines for the reviews, modified slightly in the light of the result of reviews already made, were suggested and are given in Appendix 15.5.

15.10.8 In the plans, completion of incomplete projects has been accorded higher priority than new projects. Existing irrigation projects which are not performing satisfactorily and which are amenable to improvement are no better than incomplete projects. They deserve serious attention. Investments already made on these projects should bear full fruit even if it means incurring some more expenditure to bring it about. The economic gain in the shape of larger production and greater employment opportunities will in most cases amply justify some further investment on them. Review of these projects would reveal several steps that can be taken, mostly, in the fields of agronomy, water management and operation which would enhance the utility of

these projects without any significant expenditure. All these aspects have to be examined. It is necessary that the scope for improvement of these projects and the outlay involved should be determined in a systematic manner. We, therefore, recommend that States should organise a comprehensive review of their pre-plan and earlier plan projects to be completed within five years, and formulate a programme for their improvement. The use of available water resources in a State should be examined afresh for an equitable and more productive use and the existing rights of water use need not unduly stand in the way of better redistribution.

15.10.9 Although desirable to do so, it may not be practicable to carry out all the improvements on a project simultaneously on account of financial constraints or other reasons. But it is important that there should be a clear picture of the totality of improvements which are to be brought about and work on individual aspects so carried out as to ultimately fit into this overall plan of improvement.

11 ECONOMICS AND FINANCING OF IRRIGATION WORKS

15.11.1 Before Independence, irrigation projects were required to satisfy a financial criterion for sanction. They had to be financially viable and show a profit. However, in the case of protective irrigation works, which were few and far between, this requirement was relaxed. The financial test was applied by

(i) considering the capital cost of a work as the sum actually spent on its construction ;

(ii) debiting the revenue account yearly with

  (a) the simple interest on the capital cost of the works at the commencement of the year; and

  (b) the working expenses of the year; and

(iii) crediting the revenue account yearly with direct and indirect receipts.

The difference between (iii) and (ii) above for any one year would show the profit or loss for that year. The test of financial viability was that the project should show at least the prescribed percentage return on the sum at charge in the tenth year after its opening, the sum at charge being the capital cost plus the arrears of interest up to that year. The required percentage return was fixed from time to time and ranged between 3.75 and 6 per cent. The financial criterion, which was 6 per cent between 1921 and 1949, continued to be applied for some years after Independence, though the rate kept on changing.

15.11.2 The earlier irrigation schemes were mostly diversion works

for irrigating flat lands and were relatively inexpensive. But many post-Independence schemes had storage dams and channels in undulating terrain and were in consequence more expensive. Some of these did not measure up to the financial test. It was thus felt that the rigid application of the financial criterion was a discouraging factor in the development of irrigation. Moreover, it was argued that apart from direct irrigation revenues, substantial increase in revenues accrued to the Government under income-tax, excise duties, sales tax, transport etc. Studies showed that the increase in revenues under heads other than irrigation was substantial. Further, irrigation projects conferred several economic and social benefits. In agriculture, there were higher yields, better quality crops, double cropping and agricultural diversification. Processing industries were established, consumer industries expanded and retail trade transport and communication improved considerably. With the development of irrigation there were larger incomes and greater employment opportunities in the rural economy. Thus the total benefit from irrigation was much more than the direct financial return which accrued to the Government from irrigation revenues. In 1964, the Committee to Suggest Ways and Means of Improving Financial Returns from Irrigation Projects recommended that economic benefit criterion should be adopted for sanctioning irrigation projects instead of the financial criterion. The Government accepted this recommendation and the benefit-cost ratio criterion has since been in use.

15.11.3 Before considering the merit of the benefit-cost ratio as a criterion for judging the merit of an irrigation scheme, it would be of interest to take note of certain conditions under which development of irrigation is done in the country. India is a federal republic and under the Constitution the primary responsibility for the development of water resources rests with the States. Each State, therefore, investigates, constructs and operates its irrigation projects. In the plans, the outlay for the development of irrigation is provided in the States' sector. In the complex task of formulating five year plan the judgement as to how much outlay should be provided for irrigation and how much for other heads of development such as industry, power, health, education, etc., is based on a careful study of the sectoral needs and various constraints of an overall nature. In arriving at intersectoral allocations the economic evaluation of individual irrigation projects is not an overriding consideration.

15.11.4 Irrigation projects do not individually compete with projects under other heads of development. For instance an irrigation project cannot be dropped in favour of a fertiliser project merely because the latter has a higher benefit-cost ratio or rate of return. If due to financial constraint the outlay for irrigation is squeezed that does not affect the acceptance or rejection of any individual irrigation scheme.

It merely defers the taking up of a new scheme or slows down the pace of construction.

15.11.5 Since individual irrigation projects are not in competition with projects under other heads of development, the economic criterion, whether it is benefit-cost ratio or any other, has to be applied to them only for (a) accepting or rejecting a project; and (b) fixing *interse* priority of irrigation projects. Even for determining the priority of an irrigation project a higher benefit-cost ratio or rate of return has not been the only consideration. The backwardness of an area, the extent of existing irrigation facilities there, susceptibility of the area to droughts and scarcity and the gestation period of the project all have weighed in the fixation of priority. In practice, therefore, an economic criterion has hitherto been applied to an irrigation project primarily for determining whether the project should be accepted or not. The total water resources being less than the needs, ultimately all the physically feasible projects will have to be taken up.

15.11.6 The benefit-cost criterion was first mooted for adoption by a study group headed by Prof. D. R. Gadgil in June, 1964 and was recommended later that year by the Committee to Suggest Ways and Means of Improving Financial Returns from Irrigation Projects. The Gadgil Study Group stated that "the benefit-cost ratio is not a faultless criterion and we do not want to minimise its defects". It had further stated as under :

> "2.3 The benefit-cost ratio is an efficient criterion for determining whether a project is economically viable and paying but is not so good as a criterion for ranking projects that have a benefit-cost ratio of more than one. Ranking done purely by the excess of benefits over costs totally ignores the problem of the scale of different projects being compared. But a suitable reworking of the benefit-cost calculations can give a much more accurate ranking of such projects. One such reworking we discussed was the internal rate of return. But others can be as efficient and we would like to keep the issue open for decision."

15.11.7 Increasing agricultural production is a matter of great urgency and irrigation has a key role to play in it. In order to maximise the benefit of the irrigation projects within the limited financial resources available priority has to be accorded to the most economical projects. The economic criterion to be applied to irrigation projects has, thus, not only to provide a measure for accepting or rejecting a project but should also give a satisfactory means of comparing the relative economic worth of a number of projects for fixing their *inter se* priorities. This would require a change from the criterion of benefit-cost ratio currently in use. The internal rate of return criterion has

widely been used by the International Development Association in evaluating projects posed for loans. This criterion being more satisfactory than the criterion of benefit-cost ratio is recommended for adoption in future. This departure from the recommendation made by the Irrigation Commission to continue with the use of the benefit-cost ratio criterion is justifiable in the light of further scrutiny.

15.11.8 A multipurpose project may envisage a number of benefits, such as irrigation, power generation, flood control, navigation, etc. A specific investment is needed to realise an individual benefit. At the project formulation stage, therefore, the economic test should be applied not only to the various alternatives to find out the best one but also to the various elements of benefit to determine their individual worthwhileness.

15.11.9 The cost estimates of irrigation projects do not include the cost of a command area development for which separate estimates are prepared. Yet, the full benefits of an irrigation project can accrue only after land has been shaped and field channels and field drains have been constructed. The Irrigation Commission has recommended that in making an economic appraisal of an irrigation scheme, the project cost and the cost of landshaping and of constructing field channels and field drains should all be taken into consideration. We fully agree with this recommendation.

15.11.10 There has been a suggestion that the cost of soil conservation measures in the catchment area or a portion of the cost, should also be taken into account in making an appraisal of an irrigation project, as these measures go to prolong the life of the storage reservoir. But as stated by the Irrigation Commission in paragraph 11.16 of its Report, there are practical difficulties in doing so. There are several benefits which would accrue from these measures besides prolonging the life of the reservoir and apportionment of the cost between them becomes difficult and debatable. Also problems arise when the benefit to an irrigation project accrues in a State different from that in which the catchment lies. The complications get accentuated when on a river there are a number of projects and these are taken up for construction during periods which are long apart. On practical considerations, therefore, the Irrigation Commission has recommended that the cost of soil conservation measures in the catchment area of an irrigation project need not be taken into account in making an economic appraisal of the project. We fully agree with this.

Water Rates

15.11.11 The giving up of the financial viability test for sanctioning irrigation projects has encouraged a laxity in charging appropriate water

rates to keep the projects financially remunerative. This is evident from the fact that immediately after Independence with the financial productivity test still in use, irrigation works in the country as a whole, yielded a net annual profit of over Rs. 1 crore after meeting the cost of maintenance and interest charges. Now the irrigation and multipurpose projects are incurring a tremendous loss. In 1971-72 for which figures are now available, it amounted to about Rs. 141 crores. The Statewise details are given in Appendix 15.6. We urge that at the time of considering a new project for sanction, its financial return should also be carefully examined and if found unremunerative, steps should be initiated to make the project financially viable.

15.11.12 There is a view that the provision of irrigation facilities should be regarded as a measure of social welfare and that irrigation rates should, therefore, be kept low. The Irrigation Commission examined this point of view and expressed itself in its Report as under :

> "There is a view that irrigation projects should be undertaken not so much for the purpose of earning revenue but as a measure of social welfare, and that the irrigation rates should be kept low. This approach would be valid if the benefits from irrigation projects were, more or less, evenly distributed over the entire farming community. But this is not the case, as the main beneficiaries are only a section of the cultivators in the command area. It would be highly inequitable to call upon dry-farmers and the general tax-payer to pay for benefits enjoyed by irrigators. For this we have the powerful support of the First Irrigation Commission (1901), which commented that '*Prima facie*, there is no more reason for calling on the State, or in other words, on the general tax-payer, to bear a permanent charge of, say Rs. 6 per annum, for the sake of increasing by irrigation the produce of an acre of land belonging to a private owner, than there would be for calling on it to pay a similar amount for the purpose of supplying another man's acre with manure'. We are, therefore, of the view that irrigation works, as a whole, should give an annual income at least equal to their annual cost of operation and that no part of the burden for providing irrigation should fall on the general tax-payer".

We are in full agreement with these views. The Irrigation Commission has further opined that farmers in drought affected areas should also be charged normal irrigation rates. We endorse this opinion. It has pointed out that wherever in drought affected areas irrigation has been introduced, the benefit of irrigation has been relatively more and farmers there have become as prosperous as their counterparts with similar

facilities elsewhere.

15.11.13 The irrigation rates have not been keeping pace with the rising prices and are exceedingly low. For example, during the two decades, 1953 to 1973, the wholesale price of rice rose by 169 per cent, while no change was made in the water rates for this crop in Andhra Pradesh, Madhya Pradesh and Punjab. Rajasthan raised it only by 18 per cent, Karnataka by 16 per cent and Bihar by 8 per cent. Likewise, during this period, the wholesale wheat prices rose by 118 per cent, but the major wheat growing State of Punjab made no change in the water rates. Rajasthan raised it only by 5 per cent. There has been a marked disinclination to take the unpopular but thoroughly justifiable measure of raising water rates to a proper level. As pointed out by the Irrigation Commission, the canal water rates in force for the two major irrigated crops, rice and wheat, range between 1.1 and 4.5 per cent of the value of produce, which is very low. A large part of the irrigated area in the country receives irrigation from privately owned sources and the farmers concerned incur heavy expenditure on irrigating their crops. Some of them purchase water from owners of neighbouring tubewells or lift pumps at a price several times higher than canal rates and some even share upto a third of the produce in return for the water used. It is, thus, evident that the farmer realising the key role of irrigation amongst various inputs, is prepared to pay higher water charges and has the capacity to do so. There is, therefore, hardly any justification for keeping the rates so low as to cause a loss to the exchequer and a burden on the rest of the community. The water rates in force in the various States are given in Appendix 15.7. These require early upward revision.

15.11.14 The growing of a particular crop can be discouraged to some extent by fixing a high water rate for it. As water rates, even when fixed at an adequate level, would constitute only a small fraction of the value of the crop produced, their influence upon the choice of crop by the farmer cannot be large. Punitive water rates, however, can be effective in discouraging an undesirable crop.

15.11.15 There is considerable diversity in the system of levying irrigation charges in different States. In North India, the charges are levied on crop-hectare basis, *i.e.,* the rates vary from crop to crop. In South India, the irrigation charges are merged with land revenue to be recovered as a consolidated amount. This system arose out of the fact that on early irrigation works, rice was the predominant crop, if not the only crop to be irrigated and it was, therefore, convenient to combine water charges with land revenue. In West Bengal, deltaic region of Orissa, and parts of Bihar and Madhya Pradesh, where climatic conditions made it uncertain whether the cultivators in any particular season would take water or not, a system of lease was

introduced with the intention of inducing farmers to take irrigation water by offering lower rates for long term leases. The Irrigation Commission has recommended that the prevailing irrigation rates structure in the various States should be reviewed and put on an equitable and rational basis. These are best levied on crop basis except in the case of irrigation from State tubewells where the charge can be on volumetric basis. The Irrigation Commission has set down the various considerations which would be relevant in determining water rates. To the farmer, the value of irrigation water is the net gain which he derives from its use. From his point of view, therefore, the water rate should be related to the income from the irrigated crop and not to the cost of the project concerned. As all projects do not offer to the cultivators the same quality of service in terms of adequacy and timeliness of supply, there can be differential rates based on this consideration. Rates should not vary from project to project except for quality of service. Where this is done, the disparity should not be large. The overall consideration in fixing water rates should be that, taken as a whole, the irrigation works in a State should not impose any burden on the general revenues.

15.11.16 In a number of States, like Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Tamil Nadu, an irrigation cess is charged on irrigable areas on canals in consideration of irrigation facility having been provided at public expense. The cess is charged whether the farmer takes water in any season or not and is intended to cover the maintenance cost of irrigation works which have to be maintained in any case. A two part tariff, comprising a cess as mentioned above and a water rate which is fixed cropwise but allows credit for the cess, is useful in promoting the full use of irrigation supplies. It is, however, not justified on canals with low intensity of irrigation and which do not carry sufficient supplies to meet the demand for irrigation in full. It is recommended that on canal systems where farmers are prone to speculate on rainfall in order to avoid having to pay for irrigation a two part tariff should be adopted. On new irrigation system gradually rising concessional rates in the initial two or three years might be levied as a promotional measure.

15.11.17 For economy in the use of water, supply by volume would obviously suggest itself. This mode of supply, however, is feasible only where an outlet supplies water to a single farm holding or at the most to a few farm holdings. But in India, as also in other countries with high population density, land holdings are relatively small and a single outlet serves land of many farmers. In such a situation, the metering arrangement does not work for various reasons. Earlier experiments made in the twenties in the Punjab proved disappointing. More recently, the Government of Maharashtra found the arrangement

unworkable when water was supplied on volumetric basis to three co-operative sugar factories on the Pravara Canal System. Likewise, the Government of Gujarat which accepted the principle of volumetric supply to cooperatives of irrigators did not find the system practicable. No other State has attempted to introduce it. Volumetric supply on State tubewells, however, is entirely feasible and is in vogue.

15.11.18 Irrigation being the responsibility of States, outlays for its development are provided in State plans. Because of the large requirements of major irrigation projects, it has not been possible at times to fully accommodate their needed outlays in the State plans after meeting the essential requirements of other sectors of development. This constraint has been retarding progress on many projects. Centre attempted to smoothen this difficulty in the Fourth Plan by apportioning 10 per cent of the Central assistance by giving weightage to continuing large irrigation and power projects on which sufficient progress had been made. The Central assistance to individual States took into account the amount apportioned by weightage to these projects. The outlays for them in the State plans were earmarked to ensure that the allotted amounts were fully made available. This procedure is being continued in the Fifth Plan also. Although it has helped, yet it has not completely removed the difficulty and some of the projects still do not get adequate funds for an optimum schedule of construction.

15.11.19 For planning construction of large irrigation projects on a sound basis, there has to be a reasonable assurance that funds would be forthcoming according to the stipulated construction programme. A protracted period of construction not only delays accrual of benefits but also makes the project more expensive as overhead costs increase. A large project which is apt to drag its feet due to constraint of funds in the State plan should be provided with additional funds from the Centre after ascertaining the outlay which can be reasonably met from the State plan, and the construction carried out at the optimum pace. The entire outlay for the projecct in the State Plan including the additional Central assistance should be earmarked. For such assistance only large projects that would irrigate more than 200,000 hectares need be considered. This arrangement makes it all the more important that planning of projects should be done carefully and estimates prepared correctly, price rise which cannot be forecast excepted. The estimates of all irrigation projects should be reviewed and updated atleast once in five years and in any case before the formulation of a five year plan.

12 IRRIGATION ADMINISTRATION

15.12.1 We have dealt with various features of agricultural

administration in the Chapter 62 on Administration. Here we set down our views and recommendations on certain administrative and organisational aspects of development of water resources.

15.12.2 Earlier in this Chapter, we have explained the interchange ability of surface water and groundwater in the hydrological cycle. Groundwater has its source in surface water either in the shape of the percolation of rain water or seepage from streams and canals or percolation from irrigated areas. Likewise, the dry season flows in many streams arise from groundwater regeneration. In view of this interrelationship of surface water and groundwater, the two have to be considered together in planning for development of water resources in an area.

15.12.3 An irrigation project has to supply water for raising crops. Even if all the channels are constructed for the purpose and water is made available at the outlets, an irrigation project cannot be considered complete unless water can be delivered satisfactorily to individual fields. Therefore, in an irrigation scheme, not only the storage, headworks and irrigation channels have to be constructed but also watercourses, field channels and drains have to be provided and land levelling and shaping done. In the past, development of irrigation was considerably hampered due to delay in providing the latter for lack of proper coordination between construction of project and development of commanded area. The estimates for project construction and command area development are prepared separately and outlays are also provided separately. In Section 6 we have recommended that the irrigation project report should cover both engineering works and command area development and that it should be this complete report that should be considered for sanction.

15.12.4 Soil conservation is another field of activity which has a great significance in the development of water resources. It is the land use in the catchment area, whether under forest, grass or cultivation, that determines the extent to which precipitation is disposed of by different processes such as surface runoff, infiltration and evapotranspiration. For example, infiltration of rainwater into the soil under forest is usually greater than under any other form of land use. Also forests have a great deal of regulating effect on the pattern of stream flows. They reduce sediment load in rivers and moderate flood peaks. Properly managed grassland has similar effect. Arable land in catchments, unless cultivated properly, can contribute large amount of sediment and cause high flood flows. There are several instances in the southern part of Africa of storage dams, built in watersheds already cleared for agriculture, which were threatened first by sedimentation, then, as the intensive soil conservation programmes to reduce the sediment yields succeeded, by diminution of runoff so much so that

these reservoirs now rarely fill up. Thus, a change in the land use pattern can considerably alter water resources of the catchment area, peak flows, sediment charge and the period and extent of dry season flows in streams. These are matters of great significance to those who are concerned with the development of water resources. The progressive effect of soil conservation measures and land use in catchments has to be carefully watched and evaluated. There is need for making regular observations on various important streams not only of water flows but also of sediment flows. The latter are best observed at the various river gauging stations as common facilities can be used for both the purposes.

15.12.5 The main use of water resources in the country is for irrigation. This will continue to be so even when industry develops in a big way. It is, therefore, the Irrigation authorities who have to shoulder the main responsibility for the proper development of water resources. Till October 1974, while minor irrigation including groundwater, water management, command area development and soil conservation were being dealt with in the Land and Water Wing of the Ministry of Agriculture, irrigation was the concern of the Ministry of Irrigation and Power. In the Planning Commission, however, all these subjects were in the charge of the same Member from 1967. With the reorganisation of ministries in October, 1974, irrigation was shifted to the Ministry of Agriculture which was redesignated as the Ministry of Agriculture and Irrigation. This rationalised the handling of these subjects by bringing them in the same ministry.

Organisation for Hydrology

15.12.6 Hydrological data are the very basis for a planned development of water resources. These, comprising river and stream flows, precipitation and groundwater observations have to be available extending over a fairly long period, say 30 years, for making a reasonably dependable assessment of them. At present, these are dealt with at several levels and by several organisations. At the Centre, the India Meteorological Department, the Central Water Commission and the Central Ground Water Board are concerned. In the States, the Irrigation Department and the State Ground Water Board are the main organisations that deal with the subject. But whatever data are collected in the States are mostly kept for their own use and some of them are not published at all. In view of the importance of hydrological data for the efficient development and utilisation of water resources, it is pertinent to review the organisational arrangements for them, both at the Centre and in the States.

15.12.7 At the Centre, the India Meteorological Department

(IMD) has been dealing with precipitation which is the main source of water resources in the country. The IMD receives rainfall data from an extensive network of about 5,000 raingauge stations maintained by itself or the State Governments. In addition, there are more than 3,600 non-reporting stations maintained by the Railways and other agencies. The IMD has good arrangements for rapid processing and analysis of data with the help of computers.

15.12.8 The Central Waterways, Irrigation and Navigation Commission, later converted into Central Water and Power Commission, and now Central Water Commission (CWC) was set up in April 1945, to initiate, coordinate and further schemes for the control, conservation and utilisation of water resources in the country for purposes of water power generation, irrigation, navigation and flood control. Amongst its various responsibilities, it was specifically required to undertake studies on hydrological and related aspects of water resource development and to collect, collate and publish hydrological data. The set-up of their organisation included a Directorate of Hydrology.

15.12.9 As regards groundwater, the direct responsibility for all aspects of its development lies with the State Governments. The Centre, however, has an important role to play in providing leadership in introducing new ideas and techniques, evolving methodology, laying standards and norms for planning and scrutiny of groundwater development schemes, and providing technical guidance where required. It also has to ensure coordination of research work in groundwater assessment and development. The Central Ground Water Board is the central organisation for doing all this.

15.12.10 In September 1971, the Department of Science and Technology proposed the setting up of a National Hydrological Board for improving observation and collection of hydrological data, their compilation and publication, instrumentation, and making water balance studies. The Board was to advise the Central and State organisation on the proper use of water, etc. The Board was to have a Chairman and Members from different departments and ministries including CWC, IMD, GSI, ICAR, IIT.

15.12.11 The Irrigation Commission (1972) recommended the setting up of a Directorate of Hydrology under a Director General to be attached to the Ministry of Irrigation and Power, with the following functions :

(i) the collection of gauge, discharge and sediment data for all major rivers and their tributaries at key gauging stations;

(ii) the promotion of work of preparing longitudinal and cross sections of rivers;

(iii) the standardisation and improvement of methods and procedures for the collection and assessment of hydrological

and sedimentation data; and

(iv) the periodical publication of hydrological data.

15.12.12 Recently, it has been proposed to set up a National Institute of Hydrology at Roorkee. This would essentially be a research organisation. It would be responsible for carrying out basic and advanced research on all aspects of hydrology including instrumentation and development of sophisticated techniques. This autonomous scientific institute is to have a governing council nominated by Government of India with members drawn from CWC, IMD and CGWB and some other experts connected with the subject. This is more or less what the board proposed by the Department of Science and Technology was to consist of.

15.12.13 It might be stated that one of the responsibilities with which the Central Waterways, Irrigation and Navigation Commission, now CWC, was charged at the time it was created nearly three decades ago was to undertake "studies on hydrological and related aspects of water resources development and flood control". This function yet remains to be discharged satisfactorily. There are Directorates of Hydrology, Surface Water Resources and Statistics in the CWC. If the performance of these Directorates has fallen short of expectation, it is not due to lack of expertise or even any serious inadequacy of staff. The main handicap has been the difficulty of obtaining data from the States. We are of the view that the setting up of a Directorate of Hydrology under a Director General as proposed by the Irrigation Commission would not by itself overcome this difficulty. We would, therefore, recommend that the CWC should be allowed to continue to perform its legitimate function of collecting, collating and publishing hydrological data. It should be adequately staffed and equipped with requisite equipment and aids. We further suggest that the Government of India should take steps to make it obligatory on the part of the States to furnish the hydrological data which they collect to the concerned Central organisations as may be required.

15.12.14 With the India Meteorological Department continuing to deal with precipitation, the Central Ground Water Board handling groundwater in all its aspects, the proposed National Institute of Hydrology concerning itself with all hydrological research, and the Central Water Commission collecting, collating and analysing hydrological data and publishing them, the organisational arrangements for hydrology at the Centre should be adequate. Only, these organisations have to be fully assisted to enable them to discharge their functions satisfactorily.

River Basin Commissions

15.12.15 We have pointed out in Section 6 of the chapter the

importance of preparing comprehensive river basin plans. The need for such plans was felt in early fifties and the River Boards Act was passed in 1956, empowering the Union Government to establish river boards to advise the State Governments concerned on the regulation and development of inter-state rivers or river valleys. The advice of the River Boards had to be on the basis of comprehensive river basin plans prepared after fully marshalling the necessary technical data. They were to secure the largest possible measure of agreement among the concerned States to the schemes proposed in the basin plans. In the event of disagreement between the States, the dispute could be referred to arbitration by any of the interested Governments. In setting up the river boards, the concerned State Governments were required to be consulted. Between 1961 and 1963, proposals for a number of river boards were referred to State Governments, some of which concurred while others showed reservations. By this time it was suggested that if CW&PC were suitably strengthened it could perform the same functions as were being entrusted to the boards. The upshot was that no river board was set up nor has any basin plan been prepared by the CWC.

15.12.16 The above position was noted by the Irrigation Commission (1972) and it proposed the setting up of river basin commissions by an Act of Parliament, to perform more or less the same functions as were expected of the river boards. The following functions were suggested :—

(i) to compile and analyse, basinwise, hydrological data collected by the Directorate of Hydrology and other agencies ;

(ii) to compile and analyse, basinwise, geo-hydrological and other groundwater data ;

(iii) to prepare basin plans; and

(iv) to deal with any aspect of water resources development entrusted to it for study by the Union Government or the National Water Resources Council (dealt with later on).

For the composition of the river basin commissions and the procedure to be followed by them, the Irrigation Commission stated that :

"each Commission should have four whole-time members; two senior engineers, an economist specialising in agricultural economics, and an agronomist, all of them nominated by the Union Government. One of these members will be nominated as Chairman by the Union Government. Each State Government concerned with the basin will nominate one of its Chief Engineers as a part-time member. Smaller States and Union Territories may be grouped for being given representation by rotation."

"The river basin plans prepared by the Commissions will be sent to the States for their opinion, and, thereafter, the plans

along with the views of the States and the comments of the Commissions, if any, will be submitted to the National Water Resources Council. Thereafter these plans will be forwarded to the States and the Union Government for implementation."

The main difference between the river basin commissions and the river boards under the River Boards Act 1956, is that whereas the basin plans prepared by river basin commission would go up to the National Water Resources Council for approval, and differences of opinion or approaches would be sorted out there, the disputes arising from proposals of river boards have compulsorily to go for arbitration under the River Boards Act. That can be a protracted affair and may lead to the reopening of issues on which agreement may have been secured. We, therefore, support the idea of setting up river basin commissions by an Act of Parliament.

15.12.17 The river basin commissions should examine not only the best use of water resources within a river basin but also the possible better use of part of these resources elsewhere where the need may be great and the benefit considerable. The present water use may not be the best in some parts of the country and, therefore, the existing water use should also be reviewed while formulating the basin plans. The existing laws do not cater for any inter-basin transfer of water but recourse to law for such a transfer should be taken as a last resort. Even within a basin an equitable distribution of water resources between its various parts, determined judicially, bristles with difficulties as giving due weight to each of the dozen considerations which have to be taken into account in apportioning shares is no easy task and can lead to protracted arguments. A settlement by mutual agreement is far more satisfying and is more willingly implemented than a judicial award. Mutual agreements or compacts can be greatly facilitated if at the national level there is a high powered body to lay down national water policies and which can lend its good offices in bringing about these compacts.

National Water Resources Council

15.12.18 The Irrigation Commission (1972) recommended the setting up of a policy making organisation at the highest level to :

(i) lay down broad technical, economic and financial policies in irrigation for the country as a whole, in relation to inter-State rivers and river valleys ;

(ii) suggest priorities for the accelerated development of the water resources of each region and priorities for the use of water ;

(iii) define possibilities of importing water from or exporting water to another basin, *i.e.,* the transfer of water from surplus to deficit areas ;

(iv) evolve formulae to evaluate costs and benefits when sanctioning river basin projects; and

(v) review basin plans prepared by river basin commissions, prior to sending these plans to the Union Government and to the States.

The Council was to keep a watch on the working of the river basin commissions and problems of inter-state rivers and ensure formulation of projects to conform to the highest national interests. For its composition, it recommended that "the Prime Minister of India should be the Chairman of the Council and the Union Minister for Irrigation & Power (now Minister of Agriculture and Irrigation), its Vice-Chairman. The Ministries of Finance, Agriculture, Community Development, Planning, Health, Industry and Tourism, should be represented on it through their Ministers. Major States should be represented on the Council either by their Chief Ministers or by Irrigation Ministers. The smaller States and Union Territories could have group representation, by rotation". It went on to "further recommend that two eminent irrigation engineers and the Chairman, CW&PC*, should be members of the Council" and "The CW&PC will act as the Secretariat of the Water Resources Council". We strongly support the proposal to set up this Council. We further recommend that an eminent agricultural scientist may also be made a member of the Council.

15.12.19 Some inter-basin transfers of water would be necessary for making the fullest and the best use of water resources in the country. Some interchange of water between two basins may be advantageous for reasons of economy and topography. Elsewhere surplus waters of a river may have to be taken to areas outside the basin. Even when water can be fully utilised within the basin, a portion may have to be spared for a nonriparian area because of greater need there. The existing laws do not provide for inter-basin transfer of water. While such transfers are best arranged through agreements and compacts, which may be facilitated by the proposed National Water Resources Council, disagreements cannot be ruled out. Therefore, there has to be legal provision to meet such a situation. This would involve an amendment to the Constitution. We recommend that whatever constitutional amendment is necessary for enabling a non-basin State to get water by trans-basin diversion should be made.

15.12.20 The primary responsibility for the development of water resources and that for hydrology that goes with it, rests with the States. Water resources in every State are utilised for a variety of purposes.

*Now Central Water Commission (CWC).

While irrigation is the major use, the other significant consumptive requirements are for municipal and industrial use and rural water supply. Water is drawn from surface sources or from underground. These sources have to be tapped in a planned and coordinated manner. For this there has to be a water budget with a sourcewise account of water already being used and that available for further exploitation in different areas. A track has also to be kept of the change that takes place in the total availability. This accounting would bring out any wasteful use of water and point to the danger of over-exploitation well in time before it occurs. For all this, there should be an adequate machinery. We recommend, therefore, that in every State a water resources accounting unit should be created in the Irrigation Department, that being the major water dispenser. We are glad to note that some States have already taken action in this direction. The strength of the unit would naturally vary from State to State, but should be at a level that would be effective. Also, there should be adequate arrangements for flow of information from other water-using departments.

Management of Irrigation

15.12.21 The construction and operation of major and medium irrigation schemes are essentially the responsibility of State Governments. The organisational arrangements for these differ from State to State. In most States, the project estimates provide for the construction of all works up to outlets, main drains and watercourses. Field channels and field drains are required to be constructed by the irrigators themselves. The Irrigation Department does not directly feel responsible for the development of command area which is left to be done by other departments like Agriculture, Soil Conservation, Revenue, etc. The Irrigation Department, as the purveyor of irrigation supplies, has to have a deep interest in all measures which ensure the efficient conveyance of water from its source to the field and all steps that are necessary for its fair distribution and should, therefore, feel responsible for them. A dispersed and diluted responsibility in the matter is not conducive to good result. We have dealt with this matter at some length in the next chapter.

15.12.22 The extent of responsibility of the State Irrigation Departments for the management of irrigation supplies varies. In the Northern States of Punjab, Haryana, Uttar Pradesh, Rajasthan and Gujarat, that Department is responsible for managing supplies right upto the field including distribution of water among the co-sharers on each outlet. The canal dues are assessed by that Department but are collected by the Revenue Department. In Madhya Pradesh, in the former Mahakoshal region, irrigation panchayats have been in existence

since long and have been distributing water beyond the canal outlet and collecting irrigation dues. These have been found useful in rice areas. In Maharashtra, water panchayat committees were formed in 1950-51 and are continued in many places, but it has been the experience of the Irrigation Department that the committees have not been functioning effectively. In the southern States, the responsibility of Irrigation Department ends at the outlet, beyond which it is the Revenue Department that is responsible for the distribution of water and for assessment and collection of water dues. If the Irrigation Engineer is to run the system efficinetly, he must know how and where the water is being used or misused. He can be made responsible for results only if he has a say in the distribution and utilisation of irrigation supplies. We, therefore, are of the opinion, as was the Irrigation Commission, that the system obtaining in the northern States has advantages and should be considered for adoption by other States.

13 IRRIGATION RESEARCH AND TRAINING

15.13.1 The last century saw the construction of a number of major canal systems in India. Between 1836 and 1866, the Upper Ganga Canal, the Upper Bari Doab Canal and the Krishna and Godavari Delta systems were constructed and the Eastern and Western Jamuna Canals, built earlier, were remodelled. With the undertaking of such large scale irrigation works, efforts were made to improve the understanding of various hydraulic phenomena. These research efforts were, however, individual and unorganised. Organised research commenced only in the early part of the present century and it gathered momentum after Independence. Now almost every State has an irrigation research station of its own, besides the two run by the Union Government, the Central Water and Power Research Station at Poona and the Central Soil and Materials Research Station at New Delhi. In addition, irrigation research is being carried out in a number of universities and other institutions. The research activities of these research stations are coordinated by the Central Board of Irrigation and Power.

15.13.2 We have dealt with agricultural research, education and extension in Part XI of our Report. Here we wish to draw attention to certain items of research concerning water resources and irrigation which we consider should receive more attention than hitherto. In the past couple of decades, research in the field of irrigation has tended to concentrate on materials and hydraulic structures to the neglect of hydrology and water use. Some work on water use has been done under the ICAR and in some other research stations and institutions, but a great

deal more needs to be done.

15.13.3 There is a fairly good network of raingauges in the country. The India Meteorological Department (IMD) has about 500 of them all over the country and there are many more set up by the States and other organisations. While these provide reasonably good data for estimating runoff in any year, observations in respect of snowfall and glaciers are inadequate for forecasting non-monsoon flows in snowfed rivers. The IMD should devote special attention to this task.

15.13.4 The interconnected balance between surface runoff, transpiration and infiltration gets altered on a change in the landuse. Deforestation, for example, affects the pattern of streamflow. It increases surface runoff and decreases infiltration. In arable areas, likewise, the mode of cultivation affects infiltration, it being more in terraced or flat lands or where contour sowing is done. Qualitatively these phenomena are well understood and recognised but there is need to quantify the effect which a change in landuse brings about and for this purpose observations should be organised under various conditions of landuse in large areas and particularly in respect of soil conservation measures in catchment areas.

15.13.5 Groundwater is scanty and precious in the hardrock area of the peninsula. Exploration in this area is generally expensive. Considering the importance and urgency of developing groundwater in this area which is exposed to frequent droughts, research in hydrogeological investigations and assessment techniques should be intensified and exploratory work in the area stepped up.

15.13.6 Artificial groundwater recharge has great significance in water paucity areas in some of which even wells for drinking water go dry. The technique of groundwater recharge in such areas should be developed. Hitherto, there has been no organised attempt to do so and a few experiments that have been made have been desultory.

15.13.7 There is a considerable loss through evaporation in storage reservoirs. It is proportionately higher in the case of smaller reservoirs because of their shallow depth. A good deal of utilisable water can be saved if this loss is reduced. Some research has been made with substances like cetyl alcohol and OED-70 etc., reportedly with some measure of success on one or two small reservoirs, but there has not been any real breakthrough as yet. Research with newer substances and in the technique of their application and cost reduction should be pursued.

15.13.8 A great deal of water is lost from irrigation channels through seepage. In view of the overall insufficiency of water resources in the country to meet the irrigation requirements, particularly in the low rainfall areas, lining of channels has become important. The magnitude of this work to be undertaken in future years is enormous.

It is necessary, therefore, to intensify research in lining materials and techniques which would lead to greater economy and more satisfactory results than at present.

15.13.9 We have emphasized the importance of constructing proper field drains to remove surplus water from the fields as any unwanted water there affects yields. The depth and spacing of field drains depend on the nature of soil. Some research is already being done in determining the optimum size and spacing of such drains, but there is need for expanding adaptive research in the matter.

15.13.10 The damage to crops due to prolonged root submergence varies with crop species. Even for the same crop, the degree of susceptibility to damage differs for different varieties. The information regarding the extent of reduction in yield due to root submergence for different lengths of time during different periods of crop growth is very scanty. Research in this direction need to be stepped up as it has a bearing on regulating sowing operation in heavy rainfall areas and in the choice of the right variety. It would also help in designing the field drainage more precisely and economically.

15.13.11 A fair amount of research has been made on the effect of number and timing of irrigation on the yield of wheat crop. Some research has also been done on the effect of these factors on some other crops. The data in respect of the latter are, however, inadequate and this calls for intensification of research in this direction.

15.13.12 Irrigation research should interest itself in the problems of water pollution. This is becoming increasingly important with large scale use of fertilizers and pesticides. Also increasing discharge of industrial wastes into streams and rivers is affecting river conservancy. Research in this field should, however, be fully coordinated with that being done by the National Environmental Engineering Research Institute, Nagpur.

15.13.13 The Irrigation Engineer, basically a hydraulic and structural engineer, should have some knowledge of agriculture to be able to put the irrigation supplies to the best use. He should be conversant with the water requirements of various crops during their crucial periods of growth. He should also know the extent to which yield of various crops gets affected for want of timely and adequate irrigation supplies. This knowledge is essential to enable him to regulate supplies in the various channels satisfactorily. In the past, the irrigation engineer has endeavoured to gain an insight into these matters through experience in the field. More recently, some engineering institutions have taken steps to impart education in agriculture and have included in the syllabus such subjects as soil moisture and crop water relationship, factors governing the consumptive use of water, methods of application of water, principal Indian crops, their seasons and water requirements

and use of manures and fertilisers, etc. Subjects connected with land management such as waterlogging and drainage, are also included in the syllabus. This is a welcome step and should be emulated by institutions where not already done. An engineer officer, on joining the Irrigation Department, should be given a short practical training in agriculture at an agricultural university and should also work for a short period in the Revenue Department to acquaint himself with revenue matters. Agriculture and irrigation techniques are making rapid advance. It is necessary that engineering personnel serving in Irrigation Department should keep abreast of these developments. For this purpose, there should be in-service training courses at suitable intervals.

14 SUMMARY OF RECOMMENDATIONS

15.14.1 The recommendations given below are not comprehensive. Only the more important ones are stated here for special notice.

1. On an average, precipitation in the country contributes about 400 million hectare metres of water annually. Of this, only about 105 million hectare metres can be utilised in the long run. That would suffice for irrigating about 52 per cent of the sown area of 210 million hectares expected in the early part of the next century. In view of the insufficiency of water resources to meet the requirements, there is need for a great deal of efficiency and economy in their use.

(Paragraphs 15.2.1, 15.2.16 and 15.2.17)

2. Wherever feasible surplus waters in a river, such as in the Brahmaputra, the Ganga and the west-flowing rivers south of the Tapti, should be utilised in other basins where there is paucity of water. All such possibilities should be examined and considered.

(Paragraph 15.2.13)

3. While planning for a storage scheme a study should be made to find out the effect of constructing the dam on the existing wells downstream. The study should be repeated on the basis of actual observations a few years after the construction to check on the assumption made.

(Paragraph 15.5.4)

4. In the Act that the State Governments may enact for the development of groundwater, there should be a provision that the drilling agency which drills to depths of more than 30 metres must furnish a copy of the drilling log to the state groundwater board for record and use in subsurface geological mapping. Further, the state groundwater boards should make a systematic attempt to secure

copies of logs of existing private deep tubewells for the same purpose.

(Paragraph 15.5.5)

5. The deep tubewells, because of the high cost involved in their construction and the skill and equipment required for them, are best undertaken by public-sector ; all other groundwater developments should preferably be in private sector. Jointly owned private tubewells would run for more hours than individually owned ones making them more economical and should, therefore, be encouraged.

(Paragraph 15.5.12)

6. Electric pumps are much more economical to run than diesel pumps. To encourage the former, the power requirements for irrigation pumps should be met on a priority basis and an unfluctuating and uninterrupted supply ensured.

(Paragraph 15.5.14)

7. In areas where groundwater is getting over-exploited, the State must intervene and rationalise the extraction and distribution of water. The legislation for regulating and controlling the use of groundwater is urgent specially in States where over-exploitation is already in evidence.

(Paragraphs 15.5.16 & 15.5.17)

8. If a farmer constructs a private tubewell which yields more water than what the size of his holding justifies, then it should be permissible for the farmers having contiguous holdings to avail of their share of tubewell water on payment of share cost.

(Paragraph 15.5.18)

9. Comprehensive river basin plans should be drawn up giving an outline of the development possibilities of the land and water resources of the basin, establishing priorities in respect of water use for various purposes, earmarking water for a specific purpose where necessary and indicating *inter se* priority of projects.

(Paragraph 15.6.1)

10. Irrigation policies should envisage—

(i) maximum production per unit of area through multicropping in areas with ample water resources;

(ii) maximum production per unit of water in regions of medium and low rainfall in which a large part of the country lies;

(iii) provision of maximum protection in drought areas;

(iv) irrigation of maximum area during the rainy season by supplementing rain;

(v) maximum utilisation of irrigation supplies from storage during eight months of the year excluding summer when eva-

poration losses are highest; and

(vi) conjunctive use of surface water and groundwater.

(Paragraphs 15.6.2 to 15.6.10)

11. River diversion schemes should be investigated even on non-perennial streams for *kharif* irrigation.

(Paragraph 15.6.10)

12. In formulating new irrigation projects, particularly in low rainfall areas, an attempt should be made to create irrigated plantations in compact blocks to provide fuelwood, small timber and tree fodder in the area.

(Paragraph 15.6.14)

13. Investigations of irrigation projects take a fairly long time. It is important that a number of fully investigated projects should be kept ready to choose from to suit the availability of resources and fulfilment of other considerations.

(Paragraph 15.6.15)

14. An irrigation project report should be formulated in three parts as under :—

Part I—all engineering works from source of supply to outlets and drains.

Part II—all engineering works in the command area comprising land levelling and shaping, construction of watercourses, lined or unlined, field channels, field drains and farm roads.

Part III—all other items pertaining to agriculture, animal husbandry, forestry, fisheries and cooperation.

Investigations of all the above items should be done simultaneously, and the report considered for sanction in its entirety.

(Paragraphs 15.6.16 & 15.6.17)

15. The priority with regard to the lining of channels is recommended as below :

(i) On new projects and projects being remodelled, channels which are designed to run constantly or most of the time, should be preferred because of the difficulty and in some cases unfeasibility of lining them later once they are opened for irrigation.

(ii) On existing projects the smaller channels including watercourses should be preferred because lining these would bestow greater benefit and is easier to carry out.

(Paragraph 15.6.25)

16. Research on evaporation retarders with newer materials and techniques should be intensified.

(Paragraph 15.6.28)

17. The circle system of inspection and repairs of tanks, as in

vogue in erstwhile Madras State should be introduced in all States which have fairly large tank irrigation.

(Paragraph 15.6.31)

18. Where panchayats are responsible for maintenance of tanks, they should raise sufficient financial resources through water charges for satisfactorily maintaining the tanks and should employ sufficient staff for the purpose.

(Paragraph 15.6.32)

19. There should be a suitable legislation for recovering water charges from beneficiaries of tank irrigation, at present exempt under 'Fard-abpashi' or 'Wajib-ul-arz', in order to cover maintenance cost of the tanks.

(Paragraph 15.6.33)

20. State Governments should assume necessary powers to enforce suitable cropping patterns.

(Paragraph 15.6.37)

21. The irrigation requirement in an area depends upon the type of soil, climate, contribution from effective rainfall, crop types and their duration, etc. As these vary from project to project, channels should be designed individually taking these varying factors into consideration instead of applying a uniform yardstick to them.

(Paragraph 15.6.39)

22. The schedule of channel operation should be made known to irrigators as much in advance of each cropping season as practicable to enable them to plan their cropping suitably.

(Paragraph 15.6.44)

23. Rice should be preferably grown where there is a good support from rainfall and where the soil has low permeability, say, 5 mm per day or less.

(Paragraph 15.8.8)

24. In preparing schemes for draning *Chaurs* for reclaiming land for crops, the alternative use of *Chaurs* for pisciculture should be considered.

(Paragraph 15.9.6)

25. A comprehensive review of pre-plan and earlier plan projects should be undertaken by the States to formulate a programme for their improvement. It would be desirable to complete these reviews within the next five years, so that these improvements are taken into account in the preparation of river basin plans.

(Paragraph 15.10.8)

26. In evaluating irrigation projects, the use of internal rate of return criterion is recommended. In making the economic appraisal, the cost of works and that of land shaping and construction of field channels and field drains should all be taken into consideration. The

cost of soil conservation measures in the catchment, however, need not be taken into account from practical considerations.

(Paragraphs 15.11.7, 15.11.9 & 15.11.10)

27. Irrigation works, remunerative before Independence, started showing a loss soon thereafter. The annual loss had risen to about Rs. 141 crores in 1971-72. The water rates should be revised upwards to meet the loss. In fixing these rates, the overall consideration should be that, taken as a whole, the irrigation works in a State should not impose any burden on the general revenues.

(Paragraphs 15.11.11, 15.11.12 & 15.11.15)

28. On canal systems where farmers are prone to speculate on rainfall to avoid paying irrigation charges, a two part tariff should be adopted.

(Paragraph 15.11.16)

29. In order to carry out construction of large projects at the optimum pace, Centre should provide additional outlays for them after ascertaining the outlay which can be reasonably met from the State plan.

(Paragraph 15.11.19)

30. Instead of setting up a separate Directorate of Hydrology under a Director General, the Central Water Commission should be allowed to continue to perform its important function of collecting, collating and publishing hydrological data. Its Hydrology Directorate should be adequately staffed and equipped with necessary aids. Also the Government of India should take steps to make it obligatory on the part of the States to furnish to the Central organisations the hydrological data which they observe.

(Paragraph 15.12.13)

31. The preparation of river basin plans is of great importance in the proper utilisation of the limited water resources of the country. We, therefore, support the recommendation of the Irrigation Commission to set up the river basin commissions.

(Paragraph 15.12.16)

32. There should be in every State an organisation for waterbudgeting. This is best located in the Irrigation Department, that being the major user of water. There should be adequate arrangement for flow of information to this organisation from other water using departments.

(Paragraph 15.12.20)

33. A national water resources council should be set up to lay down broad technical, economic and financial policies in irrigation for the country as a whole, keep a watch on the problems of interstate rivers and ensure that irrigation projects are formulated to conform to the highest national interest.

(Paragraph 15.12.18)

34. There should be a legal provision for the interbasin transfer of water by making the necessary constitutional amendment.

(Paragraph 15.12.19)

35. As purveyors of irrigation supplies, the Irrigation Department should be responsible for the efficient conveyance of water from its source to the field and for its fair distribution.

(Paragraphs 15.12.21 & 15.12.22)

36. More attention should be paid to the following items of research than hitherto :

(i) snow gauging and contribution from glaciers ;
(ii) effect of soil conservation measures and change in landuse on runoff and infiltration ;
(iii) hydrogeological investigations and assessment techniques of groundwater in hardrock areas ;
(iv) reduction in evaporation from reservoirs ;
(v) lining materials and techniques ;
(vi) optimum size and spacing of field drains ;
(vii) reduction in yield due to root submergence for different lengths of time during different periods of growth for various crops ;
(viii) effect on yield of the number and timing of irrigation for other crops besides wheat ; and
(ix) water pollution due to the use of fertilizers and pesticides and discharge of industrial affluents into streams.

(Paragraphs 15.13.3 to 15.13.12)

37. Essential elements of agriculture should be included in the syllabus for engineers. On joining service, irrigation engineers should be given training in agriculture for some time at an agricultural university as also in revenue matters in Revenue Department. Also in-service training courses should be held at suitable intervals.

(Paragraph 15.13.13)

APPENDIX 15.1

(Paragraph 15.2.7)

Assessment of Water Resources

Extract from the paper "Water Resources of India" by Shri Balwant Singh Nag, Member and Shri G. N. Kathpalia, Specialist (Water Utilisation) National Commission on Agriculture contributed to the Second World Congress on Water Resources—1975.

1 Water of the Earth

1.1 The water resources of the country constitute only a tiny fraction of the total water resources of the earth and it would be of interest to have a look at the latter. The total amount of water in the hydrosphere has been estimated at about 1500 million km^3. About 95 per cent of it is contained in the oceans and seas. The remaining five per cent is fresh water, of which four-fifths is stored in the form of snow and ice or permafrost. About half of this frozen water is contained in the polar ice caps. Thus the fresh and unfrozen water of the earth constitutes only one per cent of that in the hydrosphere. Bulk of it, estimated at 99 per cent, is groundwater and only one per cent is in lakes, rivers, soil and atmosphere. About half of the groundwater is more than 1000 metres below the surface and a good amount between 500 to 1000 metres. Water at these depths is very expensive to draw. Some fresh water can be obtained from the abundant sea-water by desalination, but here again the process is expensive and, therefore, use of such water can be contemplated only in comparatively shall quantities, mainly for domestic and industrial purposes. With the present stage of development of technology, it would be too expensive for irrigation. Thus, altogether, it is only a tiny fraction of the water on the earth which man can put to use as fresh water for his purposes.

2 Precipitation in India

2.1 The summer monsoon starting from the equatorial belt comes over the Indian subcontinent in two distinct currents known as the Bay of Bengal branch and the Arabian Sea branch. It has been estimated that during the four rainy months of June to September, the Arabian Sea branch of the monsoon carries moisture amounting to about 770 Mham and the Bay of Bengal and about 340 Mham of water. Of the monsoon moisture about 25 to 30 per cent precipitates in the form of rainfall. During the remaining eight months of the year also, there is a substantial amount of moisture over the country. This, however, has not as yet been scientifically assessed. It contributes a precipitation of the order of 100 Mham, a small part of it being in the form of snowfall.

2.2 Rainfall in the country varies from place to place and from year to year. It is recorded by about 3000 rain gauges set up by the Indian Meteorological Department and the State Governments. The country's average annual rainfall is about 119.4 cm and the average annual precipitation 392 Mham. This may be rounded off to 400 Mham including snowfall which is not yet fully recorded.

2.3 When rain falls, a portion of it soon evaporates from the ground or the vegetation that may intercept it, a portion soaks into the ground and the rest flows away over land as runoff. When a shower is very light, say of the order of 2.5 mm or less, it only moistens a few millimetres of top soil and then evaporates rapidly. It neither contributes to surface water nor to groundwater. There are on an average 130 rainy days in a year in the country and on 75 days the rainfall is of the above magnitude. Also, on the remaining 55 days of rainfall, there is similar evaporation at the commencement of rainfall. Taking these factors into consideration, it is estimated that out of the average annual precipitation of 400 Mham, about 70 Mham is lost to atmosphere. Of the remaining 330 Mham, about 115 Mham flows as surface runoff and the rest, 215 Mham, soaks into the ground.

3 Surface flows

3.1 The surface water flows consist of direct runoff from rainfall, snowmelt and flows in streams regenerated from groundwater. The Irrigation Commission of India has placed the total annual surface water flows in the country at 180 Mham. This figure was based largely on statistical analysis of the flow data wherever available and on suitable rainfall-runoff relationship where observed data were meagre. It includes about 20 Mham brought in by streams and rivers from catchments lying outside the country. About 45 Mham pertain to regenerated flow from groundwater as assessed from river flows during non-rainy months. The remaining 115 Mham constitute direct contribution by precipitation of which about 10 Mham is received as snowfall.

3.2 The surface water is disposed of in three ways. Part of it is stored in reservoirs or is utilised directly by diversion or pumping, part disappears as percolation from streams where groundwater table is below the stream surface and the rest finds its way to the sea, a small portion evaporating in the process. A portion of the water stored in reservoirs is lost through evaporation and a small amount through seepage; the rest is utilised for various purposes, mainly irrigation. With the construction of more projects, there would be a change in the quantities involved in the various processes through which surface water passes. More of it would be utilised and there would be less flowing down to the sea.

3.3 Of the total surface water of 180 Mham available in the country in an average year, about 15 Mham is stored in various reservoirs and tanks. There is evaporation loss of the order of 20 per cent from major and medium reservoirs and 40 per cent from tanks. The percentage loss is greater in tanks because they are relatively shallow. This evaporation loss is about 5 Mham per annum at present. But with future construction of projects, the storage water would ultimately be about 35 Mham and the loss about 10 Mham.

3.4 Of the 165 Mham of water that flows in the rivers annually at present, the utilisation through diversion works and direct pumping aggregates to 15 Mham, which is more than that from storage works. The remaining river flow of 150 Mham goes to the sea and some adjoining countries. On full development, the use of water through diversion works or direct pumping is expected to increase to 45 Mham. The balance 105 Mham would continue to flow to the sea and outside the country.

4 Infiltration

4.1 When it rains, the first claim on rainwater is that of soil to bring

the soil moisture to field capacity. Of course when the intensity of rainfall is higher than the rate of infiltration into the soil, there is surface flow even before the soil is saturated. But it is only after the soil has absorbed water to field capacity that water starts percolating down to watertable and adds to groundwater reservoir. The contribution of rainfall to groundwater in any area depends upon the intensity of rainfall, the depth and permeability of the soil and the nature of vegetable cover. On the basis of permeability of soils in different regions and the rainfall there, it has been estimated that for the country as a whole about 12.5 per cent of the total precipitation infiltrates to the groundwater table. Thus, out of 215 Mham that soaks into ground in an average year, only about 50 Mham percolates to watertable and the rest is retained by the soil as soil moisture. In future, various soil conservation and water harvesting measures should increase the groundwater recharge but that is likely to be offset by reduced percolation due to expansion of urban areas, roads and other non-absorbent surfaces. Therefore, no significant change is to be expected in the contribution to groundwater from rainfall.

4.2 In an irrigation system there are seepage losses both from channels and the irrigated fields and only a portion of irrigation supplies are actually utilised by crops. A portion of the water that seeps is retained in the soil as soil moisture and the rest percolates to the watertable. In the alluvial plains of north India, about 45 per cent of the water that is let in at the head of an unlined canal system is lost from channels through seepage. Of the remaining 55 per cent which reaches the field, another 17 per cent is lost from the field itself. Thus only about two-fifths of the water let into a canal is actually utilised. In heavier soils, or where the channels are lined, the loss is less. It is estimated that at present about 5 Mham is retained in the soil as soil-moisture and about 12 Mham is added to groundwater in this manner. On full development of irrigation in the country, the contribution to soil moisture and groundwater is expected to be about 15 Mham and 25 Mham respectively.

4.3 During the rainy season when a river is in a high stage of flow, its water surface along most of its course is higher than the adjoining groundwater table. Some river water, therefore, infiltrates and adds to groundwater. Such additions, in an average year, have been estimated to be of the order of 5 Mham. For inducing greater groundwater recharge, the watertable along the streams should be depressed through greater exploitation of groundwater before the rainy season so that a larger quantity of water may infiltrate during their high flows. In course of time when this gets done, the contribution to groundwater from rivers and streams may be of the order of 10 Mham.

5 Groundwater

5.1 With the addition of 5 Mham from flood flows and 12 Mham from irrigation systems to the 50 Mham from precipitation the total groundwater, excluding soil moisture, comes to 67 Mham. This, on development of water resources, is likely to increase to 85 Mham. A portion of the groundwater evaporates through capillary action or is drawn by plants for transpiration in areas where the watertable is high, a portion is extracted through wells, tubewells, etc. for irrigation and other purposes and a large portion is returned to the surface is regenerated flows in rivers Any portion that is not disposed of in the above manner makes an addition

to the groundwater reservoir and raises the watertable. It is estimated that at present, of the total groundwater amounting to 67 Mham replenished on an average annually, 13 Mham is extracted for various uses, about 45 Mham regenerates into rivers and the rest is accounted for by evapotranspiration and raising of groundwater table, etc. On near full development of water resources, the extraction is expected to rise to 35 Mham, evapotranspiration reduced to 5 Mham because of lowering of watertable and the remaining 45 Mham returned to surface on regeneration. It may not be desirable to reduce the regeneration in the streams by excessive extraction of groundwater, as the low stream flows in the non-rainy season consist mostly of regenerated water. These low flows in most of the streams are utilised for various purposes along their course and any reduction in them would affect these uses and also aggravate the problem of river water pollution.

6 Transpiration

6.1 Transpiration takes place from irrigated crops, unirrigated crops, and forests and other vegetation. On the basis of the prevailing temperatures and humidity and consequently the rate of transpiration, in different regions for each crop period, the amount of transpiration from irrigated crops has been estimated to be 13 Maham. Likewise, that from unirrigated crops amounts to 42 Mham and from forests and other vegetation 55 Mham. The present total transpiration thus amounts to 110 Mham. With development of irrigation, the irrigated area will increase and there will be a corresponding reduction in unirrigated cropped area although there will be an overall increase in the gross area sown. No significant change is expected in the forest area in future. On full development of irrigation, the transpiration from these categories of vegetation is expected to be 35 Mham from irrigated crops, 35 Mham from unirrigated crops and 55 Mham from forests and other vegetation, a total of 125 Mham.

7 Evaporation

7.1 In the hydrological cycle, evaporation is a major item. It has earlier been stated that as rain falls, about 70 Mham evaporates out of the total precipitation of 400 Mham. At present, about 5 Mham evaporates from reservoirs, tanks etc. and a similar amount from high groundwater areas. Of the total soil moisture of 170 Mham, which on an average is replenished annually, 110 Mham is utilised by crops, trees and other vegetation and the remaining 60 Mham evaporates. Assuming that there would be no significant change in precipitation in the near future, the evaporation from it would remain more or less the same. That from storage reservoirs, tanks, etc., would increase to about 10 Mham on development of water resources. On the other hand, with exploitation of groundwater, the area having high groundwater table and consequently evaporation from it would decrease. With an increase in the gross cropped area, more soil moisture would be utilised for transpiration and less would be left for evaporation. These reductions, however, would be relatively small.

APPENDIX 15.2

(Paragraphs 15.3.4 & 15.7.3)

Cropped Area and Irrigated Area

(million hectares)

	Reporting Area	Net areas sown			Intensity of cropping*			Gross area sown			Gross irrigated area			Percentage of gross irrigated area to gross area sown		
		1970-71	2000	2025	1970-71	2000	2025	1970-71	2000	2025	1970-71	2000	2025	1970-71	2000	2025
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Andhra Pradesh	27.4	11.7	12.4	13.0	1.14	1.35	1.35	13.3	16.7	17.6	4.2	7.3	10.2	32	44	58
Assam (including Mizoram)	7.8	2.2	2.3	2.4	1.24	1.50	1.60	2.8	3.5	3.8	0.6	1.5	2.5	21	43	66
Bihar	17.3	8.5	10.0	11.0	1.31	1.40	1.45	11.1	14.0	16.0	2.7	9.0	13.1	24	64	82
Gujarat	18.6	9.4	10.5	11.0	1.07	1.25	1.30	9.8	13.1	14.3	1.3	3.9	5.0	13	30	34
Haryana	4.4	3.6	3.5	3.4	1.39	1.50	1.50	4.9	5.3	5.1	2.2	3.3	3.3	45	62	64
Himachal Pradesh	5.1	0.5	0.6	0.7	1.67	1.70	1.70	0.9	1.0	1.2	0.2	0.2	0.2	17	20	17
Jammu & Kashmir	4.5	0.7	0.8	0.8	1.23	1.30	1.30	0.9	1.0	1.0	0.3	0.6	0.7	33	60	67
Karnataka	18.9	10.2	11.2	11.5	1.06	1.25	1.25	10.9	14.0	14.4	1.4	4.3	5.9	13	31	41
Kerala	3.9	2.2	2.2	2.1	1.35	1.45	1.50	2.9	3.2	3.2	0.6	1.6	2.6	21	50	81

Madhya Pradesh	44.2	18.4	20.2	21.0	1.13	1.30	1.35	20.6	26.3	28.4	1.5	5.9	9.1	7	22	32
Maharash-tra	30.8	17.7	19.0	19.7	1.06	1.25	1.25	18.8	23.8	24.6	1.7	5.3	6.5	9	22	26
Manipur	2.2	0.1	0.3	0.3	1.05	1.20	1.40	0.1	0.3	0.4	0.1	0.2	0.2	40	50	60
Meghalaya	2.2	0.2	0.2	0.3	1.20	1.40	1.50	0.2	0.3	0.4	..	0.1	0.1	20	25	25
Nagaland	1.4	0.1	0.2	0.2	1.00	1.20	1.40	0.1	0.2	0.3	..	0.1	0.2	12	35	45
Orissa	15.5	6.1	6.8	7.0	1.11	1.50	1.50	6.8	10.2	10.5	1.6	4.3	6.7	24	42	64
Punjab	5.0	4.1	4.0	3.9	1.40	1.50	1.50	5.7	6.0	5.9	4.2	5.0	5.0	75	83	85
Rajasthan	34.1	15.2	14.0	14.0	1.10	1.10	1.10	16.7	15.4	15.4	2.5	4.4	4.8	15	29	31
Tamil Nadu	13.0	6.2	6.8	7.0	1.20	1.35	1.35	7.4	9.2	9.5	3.4	4.0	4.0	46	43	42
Tripura	1.1	0.2	0.2	0.2	1.44	1.45	1.50	0.3	0.3	0.3	..	0.1	0.1	7	25	40
Uttar Pradesh	29.8	17.3	18.6	19.0	1.32	1.45	1.50	23.2	27.0	28.5	8.4	18.1	24.0	36	67	84
West Bengal	8.9	5.6	5.8	6.0	1.28	1.40	1.50	7.2	8.1	9.0	1.5	4.4	5.5	21	54	61
Union Territories	9.2	0.4	0.4	0.5	1.30	1.30	1.40	0.5	0.5	0.7	0.1	0.2	0.3	24	40	43
all-India	305.3	140.4	150.0	155.0	1.18	1.33	1.36	165.1	199.4 or 200.0	210.0	38.5	84.0	110.0	23	42	52

* The projected intensity of cropping has been arrived at by considering (1) rainfall, (2) irrigation potential, and (3) the need of equitable distribution of irrigation resources.

APPENDIX 15.3

(Paragraphs 15.3.4 & 15.7.3)

Irrigated Area

(million hectares)

	Net area irrigated			Intensity of cropping in irrigated area*			Gross area irrigated			Irrigated from surface water			Irrigated from ground water		
	1970-71	2000	2025	1970-71	2000	2025	1970-71	2000	2025	1970-71	2000	2025	1970-71	2000	2025
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Andhra Pradesh	3.3	5.4	7.3	1.27	1.35	1.40	4.2	7.3	10.2	3.5	5.6	8.0	0.7	1.7	2.2
Assam (incl. Mizoram)	0.6	1.0	1.6	1.00	1.50	1.60	0.6	1.5	2.5	0.6	1.0	1.8	..	0.5	0.7
Bihar	2.2	6.1	8.7	1.26	1.45	1.50	2.7	9.0	13.1	2.0	6.0	9.0	0.7	3.0	4.1
Gujarat	1.2	3.1	3.8	1.08	1.25	1.30	1.3	3.9	5.0	0.3	2.6	3.5	1.0	1.3	1.5
Haryana	1.5	2.2	2.2	1.46	1.50	1.50	2.2	3.3	3.3	1.4	2.0	2.0	0.8	1.3	1.3
Himachal Pradesh	0.1	0.1	0.1	1.56	1.70	1.70	0.2	0.2	0.2	0.2	0.2	0.2	@	@	@
Jammu & Kashmir	0.3	0.5	0.5	1.20	1.30	1.30	0.3	0.6	0.7	0.3	0.5	0.5	@	0.1	0.2
Karnataka	1.1	3.4	4.5	1.19	1.25	1.30	1.4	4.3	5.9	1.1	3.0	4.3	0.3	1.3	1.6
Kerala	0.4	1.1	1.7	1.40	1.45	1.50	0.6	1.6	2.6	0.6	1.4	2.3	@	0.2	0.3
Madhya Pradesh	1.5	4.5	6.7	1.03	1.30	1.35	1.5	5.9	9.1	0.9	3.6	6 1	0.6	2.3	3.0

Maharashtra	1.4	4.2	5.0	1.16	1.25	1.30	1.6	5.3	6.5	0.8	3.7	4.7	0.8	1.6	1.8
Manipur	0.1	0.2	0.2	1.15	1.20	1.40	0.1	0.2	0.2	0.1	0.2	0.2	@	@	@
Meghalaya	..	0.1	0.1	1.00	1.40	1.50	..	0.1	0.1	..	0.1	0.1	@	@	@
Nagaland	..	0.1	0.2	1.00	1.20	1.40	..	0.1	0.2	..	0.1	0.2	@	@	@
Orissa	1.2	3.0	4.5	1.42	1.50	1.50	1.6	4.5	6.7	1.5	3.3	5.2	0.1	1.2	1.5
Punjab	2.9	3.3	3.3	1.46	1.50	1.50	4.3	5.0	5.0	2.0	2.2	2.2	2.3	2.8	2.8
Rajasthan	2.1	3.8	4.2	1.15	1.15	1.15	2.5	4.4	4.8	1.1	2.7	2.9	1.4	1.7	1.9
Tamil Nadu	2.6	3.0	3.0	1.31	1.35	1.35	3.4	4.0	4.0	2.4	2.5	2.5	1.0	1.5	1.5
Tripura	..	0.1	0.1	1.00	1.45	1.50	..	0.1	0.1	..	0.1	0.1	@	@	@
Uttar Pradesh	7.2	12.5	16.0	1.16	1.45	1.50	8.4	18.1	24.0	3.6	7.6	11.0	4.8	10.5	13.0
West Bengal	1.5	3.1	3.7	1.03	1.40	1.50	1.5	4.4	5.5	1.5	2.4	3.0	@	2.0	2.5
Union Territories	0.1	0.2	0.2	1.25	1.30	1.40	0.1	0.2	0.3	0.1	0.2	0.2	@	@	0.1
all-India .	31.3	61.0	77.6	1.23	1.38	1.42	38.5	84.0	110.0	24.0	51.0	70.0	14.5	33.0	40.0

@ Negligible (less than 50,000 hectares).

* The projected intensity of cropping has been arrived at by considering (1) rainfall, (2) irrigation potential, and (3) the need of equitable distribution of irrigation resources.

(Paragraph 15.8.21)

APPENDIX 15.4

Irrigated Area—Cropwise

(million hectares)

	Rice			Wheat			Barley & Oats			Millets		
	70-71	2000	2025	70-71	2000	2025	70-71	2000	2025	70-71	2000	2025
1	2	3	4	5	6	7	8	9	10	11	12	13
Andhra Pradesh	3.32	2.75	3.30	0.01	..	..	..	..	..	0.24	0.95	1.20
Assam (incl. Mizoram)	0.53	0.80	1.50	..	..	..	..	..	..	..	..	..
Bihar	1.77	4.25	5.00	0.67	1.40	1.80	0.05	0.05	0.20	0.03	0.30	0.60
Gujarat	0.14	0.30	0.40	0.33	0.50	0.50	..	..	..	0.11	0.20	0.30
Haryana	0.24	0.27	0.27	0.91	1.10	1.10	0.05	0.10	0.10	0.18	0.10	0.10
Himachal Pradesh	0.05	0.07	0.07	0.05	0.06	0.06	..	..	..	0.03	0.03	0.03
Jammu & Kashmir	0.22	0.30	0.35	0.03	0.05	0.07	..	..	..	0.03	0.07	0.09
Karnataka	0.72	0.80	0.90	0.03	0.07	0.10	..	..	..	0.22	1.00	1.20
Kerala	0.49	0.40	0.50	..	..	..	..	..	..	..	..	..
Madhya Pradesh	0.62	2.07	3.00	0.52	2.00	2.50	0.04	0.05	0.05	0.01	0.05	0.10
Maharashtra	0.31	0.60	0.80	0.28	0.43	0.45	..	..	..	0.34	0.80	1.00
Manipur	0.07	0.20	0.20	..	..	..	..	..	..	..	..	..
Meghalaya	0.04	0.10	0.10	..	..	..	..	..	..	..	..	..
Nagaland	0.01	0.10	0.16	..	..	..	..	..	..	..	..	..
Orissa	1.40	2.80	4.20	..	..	..	..	..	..	0.02	0.10	0.20
Punjab	0.36	0.41	0.41	1.94	2.10	2.10	0.03	0.04	0.04	0.51	0.20	0.20
Rajasthan	0.03	0.05	0.05	1.00	1.10	1.10	0.41	0.40	0.40	0.10	0.40	0.50
Tamil Nadu	2.43	1.70	1.70	..	..	..	..	..	..	0.35	0.30	0.30
Tripura	0.02	0.07	0.07	..	..	..	..	..	..	..	..	..
Uttar Pradesh	0.75	3.75	4.50	4.00	5.00	6.00	0.74	1.15	1.40	0.30	0.70	1.10
West Bengal	1.35	2.15	2.50	0.03	1.05	1.50	..	..	..	0.01	..	..
Union Territories	0.06	0.06	0.10	0.04	0.04	0.01	0.01	..	..	0.01	..	..
All-India	14.93	24.00	30.08	9.84	14.90	17.29	1.33	1.79	2.19	2.49	5.20	6.92

APPENDIX 15.4 (Contd.)

Irrigated Area—Cropwise (Contd.)

(million hectares)

	Pulses			Sugarcane and Sugarbeet			Oilseeds			Cotton		
	70-71	2000	2025	70-71	2000	2025	70-71	2000	2025	70-71	2000	2025
1	14	15	16	17	18	19	20	21	22	23	24	25
Andhra Pradesh	..	0.20	0.50	0.11	0.30	0.50	0.26	1.40	1.50	0.01	0.50	0.80
Assam (incl. Mizoram)	0.01	0.05	0.10	..	0.05	0.05	..	0.15	0.20	..	0.05	0.05
Bihar	0.02	0.40	0.70	0.05	0.40	0.40	0.01	0.35	0.70	..	0.07	0.10
Gujarat	0.01	0.10	0.10	0.04	0.10	0.10	0.08	0.65	0.70	0.29	0.90	1.10
Haryana	0.25	0.50	0.50	0.13	0.30	0.30	0.04	0.10	0.10	0.19	0.50	0.50
Himachal Pradesh	..	0.01	0.01	..	0.02	0.02	0.01	0.01	0.01	..	..	
Jammu & Kashmir	0.01	0.01	0.01	..	0.05	0.05	0.02	0.03	0.05	..	..	..
Karnataka	0.01	0.15	0.25	0.10	0.40	0.50	0.09	0.35	0.50	0.05	1.00	1.20
Kerala	..	..	..	..	..	..	..	..	..	..	0.06	0.10
Madhya Pradesh	0.12	0.25	0.60	0.06	0.78	0.80	0.02	0.10	0.20	0.01	0.30	0.70
Maharashtra	0.05	0.40	0.50	0.20	0.60	0.70	0.03	0.25	0.30	0.07	1.40	1.50
Manipur	..	..	..	..	..	..	..	..	..	..	..	..
Meghalaya	..	..	..	..	..	..	..	..	..	..	..	..
Nagaland	..	..	..	..	..	..	..	..	..	..	..	..
Orissa	0.05	0.10	0.10	0.03	0.25	0.25	..	0.15	0.20	..	0.15	0.20

Punjab	0.12	0.15	0.15	0.11	0.28	0.28	0.09	0.16	0.16	0.39	0.70	0.70
Rajasthan	0.30	0.70	0.80	0.04	0.15	0.15	0.08	0.35	0.40	0.15	0.40	0.40
Tamil Nadu	0.01	0.05	0.05	0.11	0.27	0.27	0.22	0.35	0.35	0.09	0.50	0.50
Tripura	..	..	..	..	..	..	..	..	..	..	..	..
Uttar Pradesh	1.01	2.15	2.40	0.90	1.50	1.60	0.07	0.60	1.10	0.04	0.80	0.80
West Bengal	0.04	0.15	0.19	0.01	0.04	0.05	..	0.10	0.15	..	0.15	0.15
Union Territories	..	..	..	0.01	0.01	..	..	..	..	..	0.02	0.02
all India	2.01	5.37	6.96	1.90	5.50	6.02	1.02	5.10	6.62	1.29	7.50	8.82

APPENDIX 15.4 (Contd.)

Irrigated Area—Cropwise (Contd.)

(million hectares)

	Fodder Crops			Misc. crops including fruits & vegetables			Total		
	70-71	2000	2025	70-71	2000	2025	70-71	2000	2025
1	26	27	28	29	30	31	32	33	34
Andhra Pradesh	0.01	0.60	1.30	0.26	0.60	1.10	4.22	7.30	10.20
Assam (incl, Mizoram) . . .	..	0.20	0.30	0.03	0.20	0.30	0.57	1.50	2.50
Bihar	..	0.70	1.60	0.13	1.08	2.00	2.73	9.00	13.10
Gujarat	0.06	0.40	0.60	0.25	0.75	1.20	1.31	3.90	5.00
Haryana	0.18	0.20	0.20	0.06	0.13	0.13	2.23	3.30	3.30
Himachal Pradesh	..	..	..	0.02	0.02	0.04	0.16	0.22	0.24
Jammu & Kashmir	0.01	0.04	0.04	0.01	0.03	0.04	0.33	0.58	0.70
Karnataka	..	0.28	0.80	0.14	0.25	0.45	1.36	4.30	5.90
Kerala	..	0.10	0.20	0.11	1.04	1.80	0.60	1.60	2.60
Madhya Pradesh	0.01	0.10	0.40	0.11	0.20	0.75	1.52	5.90	9.20
Maharashtra	0.03	0.37	0.60	0.26	0.45	0.65	1.57	5.30	6.50
Manipur	..	..	..	..	@	@	0.07	0.20	0.20
Meghalaya	..	..	..	..	@	@	0.04	0.10	0.10
Nagaland	..	..	..	..	@	@	0.01	0.10	0.16
Orissa	..	0.30	0.55	0.13	0.65	1.00	1.63	4.50	6.70

Punjab	0.61	0.65	0.65	0.08	0.31	0.31	4.24	5.00	5.00
Rajasthan	0.20	0.60	0.70	0.14	0.25	0.30	2.45	4.40	4.80
Tamil Nadu	..	0.44	0.44	0.20	0.39	0.39	3.41	4.00	4.00
Tripura	..	..	..	..	0.03	0.03	0.02	0.10	0.10
Uttar Pradesh	0.23	1.25	2.50	0.32	1.20	2.60	8.36	18.10	24.00
West Bengal	..	0.26	0.36	0.10	0.50	0.60	1.54	4.40	5.50
Union Territories	..	0.01	0.04	..	0.06	0.13	0.13	0.20	0.30
all-India	1.34	6.50	11.28	2.35	8.14	13.82	38.50	84.00	110.00

@ Negligible.

APPENDIX 15.5

(Paragraph 15.10.7)

Guidelines for Review of Irrigation Projects
(To be modified to suit an individual project)

1. Name of the Project and its location
2. Cost of the Project
3. Year of completion
4. Gross command area
5. Culturable command area
6. Irrigation policy in respect of the project, i.e. whether
   (i) Maximum production per unit of area;
   (ii) Maximum production per unit of water;
   (iii) Maximum area served.
   (If not already defined, it should be laid down by Government)
7. Annual irrigation, seasonwise,
   (i) As per project report;
   (ii) Actual (average of five years)
8. Intensity of irrigation
   (i) As per project report;
   (ii) Actual (average of five years)
9. Supply available at the head of the main canal (Average of five years) during :

Kharif	June — October
Rabi	November — March
Hot weather	April — May

10. Evaporation loss from the reservoir (in millimetres), by fortnights.
11. Average rainfall in the area by fortnights (in millimetres). How much of it is effective* rainfall (in millimetres).
12. Percolation and seepage loss in the canal system both quantitatively and as percentage of the supply let in at the canal head:
    (i) main canal and branches alone;
    (ii) distributaries and minors alone;
    (iii) total loss up to outlets.
13. Is lining feasible of
    (i) main canal and branches;
    (ii) distributaries and minors.
14. Cost of lining
    (i) Main canal and branches;
    (ii) distributaries and minors;
    (iii) entire system up to outlets—(i) plus (ii).
15. Quantity of Water available at outlets (average assumed)
    (1) Without lining
    (2) with lining
        (i) main canal and branches only;
        (ii) distributaries and minors only;
        (iii) both (i) and (ii).

* Effective rainfall is that portion of the rainfall during the crop season which is available to meet evapotranspiration requirement of crops. It does not include the part of the rainfall which is lost as run-off or deep percolation below root zone.

16. Is there waterlogging in the project area and, if so, to what extent ?
17. Is the drainage system adequate ? If not, what would be the cost to make it so ? Would lining seriously affect the spring level of the wells in the area ?
18. Has consolidation of holdings been done in the command area ?
19. Are fields properly laid out and land properly prepared, including land levelling and shaping, where necessary, for irrigated agriculture? What would be the cost per hectare and the total cost for the project for achieving this if not satisfactory at present.
20. Are water courses** and field channels@ properly laid out or would they require realignment? If so, to what extent and the cost thereof?
21. Are water courses lined upto 40 hectare blocks ? If not what is the percentage loss in these, of the water delivered at outlet ?
22. What would be the cost of lining these water courses ? Also what would be the benefit cost ratio? Consider the use of underground pipelines as an alternative to lined water courses.
23. Are there field drains in the irrigated area? Are they adequate?
24. Do cultivators follow the most suitable method of irrigation in the field or do they require guidance from extension service?
25. Has a proper soil survey been done in the commanded area to determine soil suitability for the various crops?
26. State the irrigated areas under the various crops. Is the present cropping pattern suitable from consideration of soil, availability of water and climatic conditions or can there be a better pattern? State the cropping pattern in the adjoining dry areas.
27. On the basis of adaptive research, what is the optimum requirement of irrigation water (making allowance for effective rainfall, if any) in the field, for major crops in the ayacut.
28. For the cropping pattern of vogue, as also for any proposed alternative pattern, calculate the water requirements on the project:
    (i) at outlet;
    (ii) at distributary and minor head (i.e. adding losses in these channels);
    (iii) at main canal head:
        for various alternatives in respect of lining main canal and branches only;
        lining upto outlets;
        lining entire system including water courses.
29. With the storage water available in a year at the canal head, how much area can be adequately irrigated on the basis of the most suitable cropping pattern and on lining the system to the extent it is economically justified ?
30. Work out the irrigation requirement for the best cropping pattern, by fortnights.
31. Examine each channel for its adequacy to meet the peak requirement, allowing for any increase of the capacity due to lining. If the channel required remodelling, please work out the cost.
32. Is ground water available in the area for supplementing canal irrigation or for extending irrigation? What is the scope for such extension?

** A water course is a channel built at government expense to convey water from an outlet to a forty hectare block or as may be prescribed.

@ A field channel is a channel built by cultivators beyond a water course to serve the various fields within the block.

If any such conjective use is already being made, what is its extent ?

33. Are regulatory structures sufficient and adequate? In the existing regulation practice on the project, what is the pattern of closing and running of various channels in different crop seasons ? Does it conform with the actual requirements of crops ? Is any change necessary in regulation to meet the requirements of any better cropping pattern or improved crop varieties ? If so, this should be worked out.

34. (1) Which department is responsible for :

(i) maintenance of the canal system ;

(ii) regulating supplies in the canals ;

(iii) distribution of water beyond the outlets ;

(iv) proper maintenance of water courses and field channels ;

(v) making assessment of irrigation charges ;

(vi) collection of irrigation charges.

(2) Does this pattern of responsibility obtain in all irrigation projects in the States ?

(3) What are the organisational arrangements for ensuring proper coordination between the departments concerned at the time of (i) ayacut development and (ii) operation of the project ?

(4) Are the existing organisational arrangements considered satisfactory ?

APPENDIX 15.6

(Paragraph 15.11.11)

Net Contribution* of Multipurpose and Commercial Irrigation Schemes during 1971-72

(Rs. crores)

	Multipurpose irrigation schemes	Commercial irrigation schemes
Andhra Pradesh	—10.91	—12.02
Assam	..	..
Bihar	—10.89	—3.63
Gujarat	—5.35	—5.01
Haryana	—0.98	—3.15
Jammu & Kashmir	..	—0.49
Kerala	..	—1.63
Madhya Pradesh	..	@
Maharashtra	..	—12.82
Mysore	..	—14.95
Nagaland	..	..
Orissa	—5.78	—4.25
Punjab	—3.63	—3.33
Rajasthan	—3.29	—5.28
Tamil Nadu	..	—6.66
Uttar Pradesh	—4.84	—17.03
West Bengal	—4.02	—1.09
Total	—49.69	—91.34
	141.03	

* Net contribution does not constitute a commercial surplus/loss but represents excess/shortfall of revenue over non-plan working expenses and interest charges on capital outlay.

@ No commercial accounts are kept.

Source : 1. Fifth Finance Commission Report.

2. Reserve Bank of India Bulletin, June 1973.

APPENDIX 15.7

(Paragraph 15.11.13)

Canal Water Rates in Force for Principal Crops in Various States

(Rs. per hectare)

State	Rice	Wheat	Jowar, Bajra, Millets, etc.	Sugarcane	Cotton	Garden, Orchards etc.	Date of enforcement of present water rates
1	2	3	4	5	6	7	8
Andhra Pradesh							
flow canal	37.06	..	24.71	55.60	24.71	..	1-7-1962
lift canal	74.13	..	49.42	111.20	49.42	..	18-8-1967
Assam(a)							
flow canal	49.42	44.48	@	@	@	@	@
lift canal	123.55	98.24	@	@	@	@	@
Bihar(b)							
flow canal	49.42	22.24	27.18	59.31	..	..	1-6-1972
lift canal	51.39	22.24 to 39.53	19.76 to 39.53	91.43	..	..	
Gujarat							
flow canal	59.30 to 81.60	59.30 to 81.60	22.20	470.00	91.40	544.00	15-6-1971
lift canal	Do.	Do.	Do.	Do.	Do.	Do.	
Haryana							
flow canal	24.09	15.35	9.26	40.77	16.68	20.38	1949-50
lift canal	48.18	30.70	18.52	81.54	33.36	40.76	1949-50
Himachal Pradesh							
flow canal	24.27	14.58	13.96	41.09	..	20.51	1949-50
lift canal	48.54	29.16	27.92	82.18	..	41.02	1949-50

Jammu & Kashmir							
flow canal	13.04 to 16.06	8.65	6.10	16.06	..	6.52 to 9.88	15-3-1972
lift canal	39.52	39.52	19.76	39.52	..	39.52	
Karnataka							
flow canal	49.42	29.65	29.65	98.84	29.65	59.31	1-7-1972
lift canal	For lift irrigation, no rates as yet have been specified.						
Kerala(c)							
flow canal	37.00 to 99.00	..	..	..	..	..	1-7-1974
lift canal	The rates are one and a half times flow rates.						
Maharashtra							
flow canal	37.50 to 57.50	57.50	37.50	510.00 to 660.00	170.00 to 187.50	340.00 to 435.00	1-7-1974
lift canal	45.00 to 78.00	78.00	45.00	625.00	200.00	625.00	1973-74
Madhya Pradesh							
flow canal	39.54 to 59.31	37.01 to 49.42	19.77 to 24.80	98.84	39.54	98.84	1-8-1972
lift canal	Double the flow irrigation rates.						
Orissa(d)							
flow canal	2.47 to 9.88	14.82	12.36	44.48	24.71	29.65	15-11-1973
lift canal	28.80 to 120.00	36.00	57.60	108.00	48.00	N.A.	
Punjab							
flow canal	48.19 to 48.83	13.59 to 14.93	24.09 to 24.39	66.72 to 67.83	32.54 to 38.92	50.86 to 51.40	1-6-1974
lift canal	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

APPENDIX 15.7—(*Concld.*)

1	2	3	4	5	6	7	8
Rajasthan							
flow canal	34.60 to 61.78	29.65 to 37.07	17.30 to 29.65	74.13 to 86.49	49.42 to 61.78	84.02 to 123.56	23-11-1974
lift canal	Rs. 19.76 per watering per hectare subject to a minimum of Rs. 24.71.						
Tamil Nadu							
flow canal	37.07 to 49.42	..	18.53 to 24.71	49.42	49.42 to 61.78	49.42 to 61.78	23-10-1969
lift canal	37.07	..	18.53	..	49.42	49.42	
Uttar Pradesh							
flow canal	11.86 to 51.89	38.62 to 46.33	12.36 to 27.03	29.65 to 48.27	6.18 to 17.40	12.36 to 54.06	1-10-1972
lift canal	51.89	46.33	27.03	48.27	17.40	54.06	
West Bengal(e)							
flow canal*	9.90 to 30.90	6.20 to 37.10	..	37.10	..	..	1958
lift canal	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	

N.A.—Not available.

(a) In addition, maintenance cost of Rs. 19.77 per hectare per crop for flow irrigation and Rs. 74.13 for rice, Rs. 61.78 for wheat and other Rabi Crops per hectare for lift irrigation are also proposed.

(b) Since August, 1974 the rates for flow irrigation have been increased to one and a half times the rates indicated against the State.

(c) The rates of flow canal vary with type of land.

(d) Since Nov. '74 the rates for paddy have been doubled and the rates for the other crops have been increased to one and a half times of the rates given here.

(e) According to communication from Irrigation and Waterways Department, West Bengal, a bill has been prepared in which substantial increase in irrigation rates is proposed for supply of water from projects under the Department, other than DVC.

@ Proposed rates are not yet in force.

* Rates given on the basis of season and not crop-wise.

Note :—The Water rates of Lift Canal relates to the Lift Irrigation at Government Cost.

16

COMMAND AREA DEVELOPMENT

1 INTRODUCTION

16.1.1 In the preceding Chapter on Irrigation, we have dealt with policies and measures for harnessing water resources for irrigation and managing irrigation works. Governmental agencies are responsible for constructing and managing all irrigation works that are taken up in the public sector. These works comprise major and medium irrigation schemes, most surface minor schemes, and the State tubewells. Watercourses and in some cases field channels are constructed by project authorities but are required to be maintained by the irrigators. We have, however, recommended in the preceding chapter that watercourses and field channels where lined should be maintained by the Government agency. The management and the actual use of irrigation supplies beyond the outlet of an irrigation channel rests with the irrigators. Government, however, has a responsibility to ensure that water is not wasted and is distributed equitably. Government also has to see that water is utilised in a most productive manner and has, therefore, to provide the irrigators with the necessary guidance and assist them with the necessary inputs.

16.1.2 An irrigation project should not be looked upon merely as a means of providing water for irrigating crops. It in fact offers an opportunity to change over from the uncertain and often precarious rainfed cropping with low yields to scientific irrigated cropping making full use of the technological developments in irrigated farming. It provides an occasion for reorganising the entire farming structure in the area for the maximum facility and benefit to the farmers. The steps to bring this about are many and have to be taken in a systematic and well organised manner. Irrigation water can be put to a satisfactory productive use only if the command area is fully ready to receive the supplies. For this, the land has to be properly formed, fields preferably laid out in proper sizes, watercourses and field channels

constructed to carry water to individual fields, field drains provided to remove unwanted water which may affect the crops, farm roads provided for easy access to fields for transporting inputs and produce, and dispersed fields of individual farmers consolidated into one or two operational holdings. The scope and extent of these measures are influenced by topography, nature of soil, pattern of cropping and the mode of irrigation. Besides the above measures, adequate and timely supply of inputs has to be ensured and marketing and other infrastructure facilities provided, so that the farmer is able to derive the maximum benefit from raising irrigated crops.

16.1.3 Most of the large pre-Independence projects served flat areas with alluvial soils. The Upper Bari Doab Canal, the Western and Eastern Yamuna Canals, the Upper and Lower Ganga Canals, the Agra Canal and the Sarda Canal irrigated areas in the Indo-Gangetic plain. The Godavari, Krishna and Cauvery systems in the south served areas in the deltas of these rivers. All these had level lands and required little by way of landshaping or terracing and not much effort and skill in digging watercourses and field drains. Under these conditions, after the completion of an irrigation work the State's responsibility was limited to the maintenance of headworks canals and distributaries, the supply and distribution of water at the outlet, and the assessment and collection of water charges. For all other requirements the farmer was left to his own device. The development of irrigation was thus naturally slow and often took a decade or more on a project.

16.1.4 After Independence, recognising the crucial importance of developing irrigation to increase crop production, a large number of irrigation projects were taken in hand. Amongst them were some giant projects like the Bhakra Nangal, Hirakud, Tungabhadra, Nagarjunasagar, Chambal etc. Altogether in the First Plan there were 27 major and 240 medium projects under implementation. Many more were taken up in subsequent plans. These projects were considered and sanctioned in the manner of pre-Independence projects with no provision for command area development. The estimates, however, included the cost of construction of watercourses in most cases. The Irrigation Department did not feel responsible for command area development which was regarded as the concern of other departments, such as Agriculture Department and Revenue Department and above all of the farmers themselves. The utilisation of irrigation supplies was consequently tardy. The irrigation projects were expected to take 10 years for full development. The urgency of increasing agricultural production and the income and employment opportunities in the rural areas drew pointed attention to the importance of rapid command

area development. In the Third Plan document certain measures necessary for securing speedy benefits from irrigation projects were set down. All the suggested steps were in the right direction but more were required. In the Fourth and Fifth Plans some special programmes of command area development were taken up. Projects, however, still continued to be prepared for engineering works alone and not in a comprehensive way as indicated in Chapter 15 on Irrigation. In this chapter we have dealt with the elements that should be planned for and incorporated in that portion of the comprehensive irrigation project report which pertains to command area development.

2 SOIL AND SOIL SURVEYS

16.2.1 In formulating an irrigation project, amongst other things, an examination has to be made of the suitability of the area for irrigated cropping, the long range behaviour of the soil under irrigation and the steps that would be necessary for continued fertility and good productivity of the soil. Besides climatic conditions, the texture and depth of the soil, its ingredients, salinity and alkalinity status, drainage condition, and the position of groundwater table, all go to determine the crops which would be suitable for the area and the mode and extent of irrigation to be applied to them. The depth and frequency of irrigation are related to the nature of soil. The greater its water-holding capacity, the greater will be the irrigation depth and in consequence the lower the irrigation frequency. The nature of soil, thus, has a great significance both in formulating an irrigation project and in operating it.

16.2.2 We enclosed a soil map of India, drawn to a scale of 1 : 6 million, in our Interim Report on Soil Survey and Soil Map of India. The map gives a broad picture of the variety of soils which obtain in different parts of the country. In it, 26 soil types were identified and depicted. But for irrigation planning, soils can be classified into four major soil groups, namely (a) alluvial soils (b) black soils (c) red soils and (d) lateritic soils. Besides these, of less importance are forest soils, desert soils, saline and alkaline soils. Their composition, properties and behaviour under irrigation differ. These weigh in crop planning for the area and in determining the mode of irrigation.

16.2.3 Alluvial soils cover by far the largest part of the country, predominantly in the Indo-Gangetic and the Brahmaputra valleys and the deltas of the major rivers. These soils, deposited by the rivers,

vary in their consistency from drift sand to loams and from fine silts to clays composed mainly of illite. Mostly they are suitable for irrigation and are easy to drain. Because of their good permeability, they take more water for growing water-intensive crops like rice than the less permeable soils do. In certain areas, particularly Uttar Pradesh, Punjab, Haryana and Delhi, there are layers of hard pan at different depths in the soil profile. These obstruct percolation and at shallow depth hamper root growth. These areas are apt to get waterlogged when irrigated unless preventive measures are incorporated in the irrigation project.

16.2.4 The black soils, formed by weathering of basalt, gneisses and schists, predominate in Maharashtra, Saurashtra and western part of Madhya Pradesh. They are also found in parts of Karnataka, Andhra Pradesh, Tamil Nadu and South Bihar. They are fine textured with clay content mostly ranging between 40 and 60 per cent; the clay mineral is predominantly montmorillinite. They are plastic and sticky when wet but very hard when dry. They develop deep cracks on drying, which close up again with the swelling of the soil on getting wet. Because of the fineness of their texture, they have good water holding capacity and this permits irrigation of crops at longer intervals than in alluvial soils. These soils, however, contain a fair amount of salts in their profile and unless irrigation is properly controlled, the area tends to become salt infested. Provision of adequate drainage in irrigated areas having such soils is essential not only to prevent salinity and alkalinity problems arising there but also to prevent sogging of crop root zone. Black soils are fairly rich in plant nutrients and if properly managed can give good crop yields. They, however, vary in depth a great deal from a few centimetres to several metres and this factor becomes an important consideration in laying down cropping pattern for various parts of the command area of a project.

16.2.5 Red soils cover the largest area in the country next to alluvial and black soils. They are found extensively in Tamil Nadu, Karnataka, Andhra Pradesh and Madhya Pradesh and also occur in parts of Maharashtra, Bihar, Orissa, West Bengal and the North Eastern States. These soils generally have a good permeability and in consequence low moisture retaining capacity. They are friable and internally well drained. They are quite suitable for irrigation. In many situations red and black soils occur side by side, the former at higher levels and the latter at the foot of the slopes and in the valley. Growing water-intensive crops like rice in the higher red soils tend to waterlog the black soils lower down, rendering them unfit for growing crops other than rice. In prescribing cropping pattern for such

areas this aspect has to be borne in mind.

16.2.6 Lateritic soils are essentially composed of a mixture of hydrated iron and aluminium oxides and kaolinite. These soils occur basically on hill tops and may be carried to lower levels by streams to form detrital deposits. These soils have a relatively low content of organic matter and primary minerals, and having a high degree of porosity drain well. They are generally acidic with pH value ranging between 5.0 and 6.0. The higher their level, the more acidic are these soils. The main plantations raised on these soils are tea, coffee, rubber and cincona at higher levels and coconut, cashewnut, mango etc. elsewhere. In Tamil Nadu and Kerala paddy is also grown in low level areas which remain wet because of infiltration of water from higher levels.

16.2.7 Desert soils cover an extensive area in Rajasthan and the contiguous parts of Haryana and Gujarat. These soils are generally poor in organic matter and have a high percentage of soluble salts. However, given irrigation facilities, as in Rajasthan Canal Command, good crops can be raised on these soils. Forest soils and peaty and marshy soils are rare in canal command areas and these, therefore, do not have much significance concerning irrigation. Salt affected soils occur in the Indo-Gangetic plains, in the medium and deep black soil regions of Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh, in the arid regions of Rajasthan and Gujarat, and in the coastal areas. As soil and climatic conditions differ in these areas, the methods of reclamation and of subsequent utilisation of reclaimed lands also differ a great deal. But in all cases the reclamation is a protracted and expensive process. Heavy irrigation or continuous flooding over a period can reclaim these soils provided there is good natural drainage and the ground water table is low.

16.2.8 Soil surveys constitute an important item of investigation of an irrigation project and project reports have been required in the past to specially deal with it. Aerial surveys are very useful for getting a speedy broad idea of the nature of the prevalent soil. Aerial photographs are available with the Survey of India for the entire country, but for certain areas these are in the restricted category and can be had only with special permission. Photo interpretation requires to be supplemented with field surveys by taking samples from boreholes and analysing them. The samples have to be taken close enough to cover the various soil types in the area. The boreholes have to be deep enough, say over 3 metres, to give a good idea of the soil profile. Normally, samples taken one for every 1,000 hectares suffice for project formulation. But a more detailed survey is necessary for the command area for determining cropping patterns suitable for it. For

this purpose, a sample for every 50 hectares is required to be taken. Later, when the area has been brought under irrigation a still more detailed soil survey of the various operational holdings should be carried out to find out the deficiency and excess of essential constituents and the kind and quantity of fertilisers and amendments that need to be applied. Soil properties keep on changing with time, being affected by the crops grown and the fertilisers etc. applied. Soil surveys have thus to be repeated periodically to keep a track of these changes. We invite a reference to the Interim Report on Soil Survey and Soil Map of India which we submitted to the Government in August 1972.

3 LAND PREPARATION FOR IRRIGATION

16.3.1 In north India, land development on new projects has not been a serious problem as the soils there are easy to handle and the farmers already familiar with irrigated crop husbandry and eager to make use of canal water, would set about preparing land to receive irrigation supplies without much assistance or persuasion. It is only on Rajasthan Canal Project that special arrangements have been necessary for levelling land in its extensive dune areas. In south India also wherever a project has been carried out to irrigate existing rice areas the utilisation of water has been rapid. This has been remarkably so in many projects in Kerala State as lands there were ready for irrigation. Elsewhere in the peninsula area with more clayey soils the development has been slow and difficult particularly where farmers did not have previous experience of irrigated crop husbandry.

Main Steps for Land Development

16.3.2 For land development in command area a number of steps have to be taken. These comprise—

(i) layout of plots and of common facilities like watercourses, field channels, drains and farm roads;
(ii) consolidation of farmer's scattered plots into one or two operational holdings;
(iii) construction of watercourses and field channels;
(iv) construction of field drains where necessary and linking them with connecting drains;
(v) construction of farm roads; and
(vi) land formation to suitable slopes.

These steps have to be taken in a systematic manner. Firstly, layout plans and designs have to be prepared on suitable maps marking out land for watercourses, field channels, field drains and farm roads

as also the plots laid in suitable sizes and direction. Although land development has to be compulsory, the salient features of the proposal should be explained to the farmers concerned and their views elicited. The layout plan, modified if necessary, should then be used for demarcating holdings for individual farmers. In the process of consolidation of holdings, while the layouts would be prepared for the commands of individual outlets, allocation of holdings would be on the basis of consolidation operation for the entire village. Once the layout plan is finalised, work on the construction of watercourses, field and connecting drains and farm roads can be proceeded with even before the work of consolidation of holdings is completed. The work of land formation can be taken up only after the allotment of holdings is done as individual farmers have to accept responsibility or liability for land formation.

16.3.3 A scheme of land development in a command area can be prepared only if suitable maps for the purpose are available. These have to be more detailed and on a larger scale than are required for preparing an irrigation project. While for project formulation topographic maps to a scale of 1:15,000 with contours at one metre interval are often used, the maps for command area development have to be to a scale of 1:2,500 or 1:4,000 with 10 cm contour interval. Where the terrain is steep the scale will need to be still larger for this contour interval. For most parts of the country, village maps to 1:4,000 scale are available. These are not accurate enough for purposes of land formation and fresh maps in most cases will need to be prepared for areas actually requiring land formation. We have dealt with the organisational aspect of map preparation later on in Section 6 on Organisation.

16.3.4 In addition to the topographical maps, soil and land classification maps of the area are required. The cropping pattern, the mode of irrigation, the slope to which land need to be graded, the size and spacing of drains, etc. all have to take into account the nature of the soil. For preparing soil and land classification maps, soil samples should be analysed of each soil series and sometimes of each soil phase in the area. The technique, norms and procedure for preparing these maps are now well established. For preparing the scheme of command area development it should suffice to carry out only sample surveys of representative areas and not wait for the completion of the entire detailed survey work which, of course, would be required later for the actual implementation of the scheme.

Methods of Irrigation

16.3.5 Among the factors that determine the most suitable method

of irrigation in a particular situation are the slope of the land, the crops to be raised, the rate of infiltration and water holding capacity of the soil, and the extent and nature of the availability of irrigation supply. The mode of irrigation should ensure sufficient water to satisfy the need of the plant but not so much as to lead to waste and damage. The method of irrigation selected should conserve both soil and water. It may be necessary to use more than one method of irrigation in a field each suiting a particular crop.

16.3.6 Irrigation water can be applied to a field either by flooding thus wetting the entire land surface or through furrows thereby wetting only part of the surface. Sprinkler irrigation which simulates rainfall or drip irrigation which moistens soil around individual plants, are not significant in the context of command area development. For flood irrigation land is prepared either in border strips or check basins. The border strips can be laid along the general slope of the field as graded borders or laid across the slope as contour borders. In check basin method water is applied to small, relatively level plots into which a field is divided. Furrows can be classified into (a) graded furrows when laid down the prevailing land slope, (b) level furrows when fairly level lengthwise and (c) contour furrows when laid across a sloping field along its contours. For close-growing crops or crops sown by broadcast corrugation method of irrigation is sometimes adopted. Corrugations are merely shallow closely spaced furrows and like them can be graded, level or contour type. The significant difference between furrow and corrugation method of irrigation is that in the latter case plants need not be in a row along the corrugations which are usually formed after sowing but before the germination of seeds.

16.3.7 For border irrigation, the width of the long parallel strips, called borders, is governed by the size of the irrigation stream and the degree of land levelling practicable. It can vary from 3 to 15 metres. A small irrigation stream would require narrow strips and in consequence more separating ridges than in the case of a large stream. If the width is less than twice the turning circle of a tractor, that is about 15 metres, it interferes with the operation of machinery. The length of the border is governed by the nature of the soil and can be 60 to 120 metres in sandy and sandy loam soils, 100 to 180 metres in medium loam soils and 150 to 300 metres in clay loam or clay soils. It is important that the borders should have uniform longitudinal slope and should be level across. While a minimum slope in the borders, as also in furrows, is necessary for irrigation, the slope has to be kept flat enough so that the soil may not get eroded by the irrigation stream and rainfall. The recommended safe limits of land slope for different types of soil are :

(i) heavy (clay) soils 0.15 to 0.35 per cent.
(ii) medium (loam) soils 0.2 to 0.4 per cent.
(iii) light (sandy) soils 0.25 to 0.65 per cent.

The border method of irrigation is most suitable for close growing grain crops such as wheat, barley and fodder crops.

16.3.8 In designing contour borders the same considerations and criteria apply as for graded borders. Only the slope of the land becomes an additional factor in fixing the width of the borders as a series of steps are formed down the slope. A reasonable drop from step to step is about 30 cm and normally it should not be more than 60 cm from consideration of cost of earthwork and maintenance of the borders. It saves on earthwork if the contour borders follow closely the original topography.

16.3.9 In check basin method of irrigation, a field is divided into relatively small and fairly level plots and water is let into the individual plots from a field channel running along them. The plots called check basins are generally rectangular but need not be so and may follow the contours of the land surface. The size of ridges enclosing the basins depends upon the depth of water to be impounded and the stability of the soil when wet. This method of irrigation is particularly suitable for heavy soils as water has to be kept on them longer because of their low rate of infiltration. Rice crop is mostly irrigated by this method. The method is useful also in leaching soils for removing excessive salts and is efficient in conserving rainwater and soil.

16.3.10 Furrow irrigation is suitable for all row crops like maize, jowar, bajra, sugarcane, cotton, tobacco, groundnut, potato, vegetables and plantation crops. It is most suitable when the crops are sensitive to ponded water, like beans and potato, or susceptible to fungal root rot or root injury like sugarbeet, safflower and castor. Normally one row of crop is planted on a ridge but in the case of groundnut and certain vegetable crops like chillies, onion, cabbage, etc. a row may be planted on either side of the ridge.

16.3.11 In surface method of irrigation, the water application efficiency, that is, the percentage of water applied that goes to increase the soil moisture in the root zone of a crop, depends on how carefully the field is prepared to receive irrigation water and how well the supply is regulated. An excessive dose of water lowers the efficiency due to percolation of water below the root zone or runoff from the lower and of the field. According to FAO,[1] the efficiency of application of water

1 Irrigation Practice and Water Management, Food and Agriculture Organisation, Rome, 1971.

by different methods of irrigation is as under :

Method of irrigation	Efficiency of application (percentage)
basin and level borders	60-80
border	40-75
furrow	55-70
corrugation	50-70
contour Channels	50-55
sprinklers	65-85

The range of efficiency is quite wide. On heavy soils with their low infiltration rates, higher efficiencies are possible with short run for furrow and border irrigation.

16.3.12 Land from consideration of its slope can be classified[1] as under :

Class I(a)	—slope between 0.02 and 0.1 per cent (1 in 5000 to 1 in 1000)
Class I(b)	—slope between 0.1 and 1.0 per cent (1 in 1000 to 1 in 100)
Class II	—slope between 1.0 and 3.0 per cent (1 in 100 and 1 in 33)
Class III	—slope between 3.0 and 5.0 per cent (1 in 33 to 1 in 20)

Major portion of the alluvial tracts of the Indo-Gangetic basin and delta areas fall in Class I(a) and most of the land in the rest of the country in the remaining classes. Land preparation for irrigation on steeper slopes becomes expensive and in areas with natural slopes exceeding 10 per cent it may cost so much as to make introduction of irrigation there uneconomical.

Layout in Outlet Commands

16.3.13 In an irrigation project the unit for purposes of designing layout for irrigated land is the command area of an outlet. Ideally, within this command area each field should be approachable for transport of inputs and harvest, and have the means of receiving irrigation supplies and of removal of surplus irrigation or rainwater which may cause damage to the crop. The farm road and the field drains obviously have to be properly connected with those in the neighbouring areas to ultimately link up with the main ones. Therefore, while the layout in the command of an outlet has to be complete in itself, for proper linking it cannot be designed in isolation. Consolidation of holdings is a pre-requisite to proper layout in a command area. During the process of consolidation of holdings, land can be earmarked for farm roads, watercourses and connecting drains, and the fields relaid to proper length and width and to suit the natural slope of land for facility of

1 Handbook on Irrigation Water Management. Ministry of Agriculture and Irrigation, Government of India, New Delhi, 1971.

land levelling. It is not necessary that all field boundaries should be straight. Fields would be just as easy to cultivate if they were to follow the natural contours of the land to avoid extra earth movement. However, triangular fields and fields with acute angled corners should be avoided as they are difficult to cultivate.

16.3.14 A good layout has to be simple with a minimum length of watercourses and drains and a minimum of cross structures. One test of a good layout design is to find out the percentage of the land taken up by farm roads, watercourses, and drains to the total area. Different layouts for an area can thus be compared and the most advantageous one adopted, taking into account other factors such as the quantity of earth to be moved in shaping the land. To illustrate, a layout for an outlet command having large fields and another one with small fields are shown in Maps I and II.

Watercourses

16.3.15 In a good layout every operational holding should get water directly from the watercourse, which may have to branch off into two or more sub-watercourses or field channels. The total length of a watercourse in the command on an outlet may vary from 2 to 4 km. The length would be relatively short in rice areas. In light soils where seepage losses are high, it is desirable to line the watercourses. As lined watercourses are expensive, it is important that their length should be kept short by avoiding zigzag routes. The length of even unlined channels should be kept minimum to save on seepage losses.

Field Drains

16.3.16 In irrigation projects the practice till recently has been to provide only feeder drains for carrying drainage water to the main drain. No field drains were provided and drainage was expected to take place from field to field till it reached a feeder drain. For want of field drains during a heavy downpour water would often stand in a field for a long period. Attempt to drain it off through a neighbour's field often led to dissensions. Crops suffer heavy damage whenever water is allowed to stand in a field for a long period. Even rice crop suffers a great deal when plants remain submerged beyond a certain period. The percentage reduction in yield for different periods of submersion during different stages of plant growth for rice crop observed in Japan and Korea are given in Appendices 16.1 and 16.2. In the case of light irrigated crops, the damage due to root submergence arises on account of obstructed aeration of soil thereby inhibiting

normal respiration. Also, in some cases it causes root rot.

16.3.17 No uniform norm can be prescribed for providing field drains in irrigated areas. The requirements of rice fields are different from those of other crops. It is the intensity and pattern of rainfall and the nature of soil which determine the design of the drainage system. In light soils because of their good internal drainage, a good deal of water standing in a field seeps down quickly relieving to that extent the surface drains. In heavy soils on the other hand because of their low permeability and high water retentive capacity surface drainage is very important, as the heavy soil once it becomes soggy remains so for a fairly long time. Generally, field drains can be designed to cope with heavy cloud burst of once in five years frequency. The main drains need be designed for once in ten years frequency. The obvious location for a field drain is at the lower end of the field, that is, on the side opposite to the watercourse.

Farm Roads

16.3.18 Ideally, each field should abut a farm road for direct access without having to pass through another person's field. This becomes important where in a command area a variety of crops are grown in a season with different sowing and harvesting times. An attempt has, therefore, to be made to provide independent access to each field to the extent feasible. Farm roads can be laid either along watercourses or along field drains ; the latter is preferable. Watercourses as a rule, have to be at a higher level than the adjoining fields to be able to irrigate them. A farm road laid along the watercourse will have to cross the various inlets to the fields with possibility of wastage of water there and damage to the road. On the other hand, if the farm road is laid at the lower end of the fields in the trough with field drains on either side, the farm road would mostly remain dry and unaffected by flow of water in the side drains, which normally would be below the level of adjoining fields. The earth from drain excavation can be utilised in road formation and that from its clearance for road maintenance. The farm road can be 3 to 3½ metres wide and about 20 to 30 cm above the field level. Farm roads should be provided with properly laid pipe crossings from the fields to the drain. In heavy rainfall the farm road with its side drains can act as a shallow wide drain being at the lower end of the fields. With two side drains, the farm road would provide sufficient clear width for a harvester combine to be taken over it.

Consolidation of Holdings

16.3.19 We have dealt with the subject of consolidation of holdings

in Chapter 68. In the present chapter we wish to emphasise its importance in relation to command area development. In fact, consolidation of holdings is essential for a proper layout of watercourses, field drains, farm roads and the fields themselves. During the process of consolidation, land can be earmarked for these and other common purposes. It has been experienced that when consolidation of holdings forms a part of a much wider development programme such as command area development, there is less hesitation on the part of the farmers in agreeing to it. The planning of land development, including construction of watercourses, field drains and farm roads, has to go hand in hand with consolidation of holdings. On the updated contour map of command area should be marked the most suitable alignments of the above items, taking into account the requirements of land formation. After taking out the area required for these purposes, the remaining area can be parcelled out in consolidated holdings on the basis of the productivity value of each field. Other measures required under land reforms such as enforcement of land ceilings, allotment of surplus land etc. can be carried out at the same time. It is desirable that small holdings should be grouped in a contiguous area near the periphery of the village. Within the command of an outlet, the smaller holdings should be located at the beginning of the watercourse and the larger ones farther away. This would facilitate equitable distribution of water to the smaller holdings. Sometimes the multiplicity of tenurial system and absence of uptodate record of rights may present difficulty in the consolidation work and prolong the process. Where such a situation exists, the work of updating the record of rights etc. should be taken up well in advance of the work on the irrigation project. In some States, mostly in the South, the irrigated land can be divided into three categories, namely, rice lands, plantation lands, and lands under other crops. If a farmer owns lands of more than one category, then it is better to let him have more than one holding on consolidation.

16.3.20 Consolidation of holdings, by itself, confers a great deal of benefit to the farmers in the shape of increased production. A study[1] made in the undivided Punjab some years ago revealed that without any change in the method of cultivation, an increase in agricultural production of 25 per cent resulted from land consolidation alone. In another study[2] made in Uttar Pradesh in 1962-63, it was found that consolidation of holdings gave a substantial saving on human and bullock labour and gave an increase of 35 per cent in jowar crop and 12 per cent in rice crop. The cost of production of individual crops got reduced from 15 to 49 per cent and the output-input ratio rose by 14 per cent.

1 1971, Randhawa M. S., Towards a Planned Countryside (Progress of consolidation of holdings in Punjab) New Delhi, Planning Commission.

2 1971, Agarwal S. K., Economics of Land Consolidation in India, New Delhi, S. Chand & Co.

16.3.21 All the steps necessary for development of land in a command area have to be taken together in an integrated manner. It is not only impracticable but is unduly expensive to cater for one requirement at a time. For instance having provided watercourses unrelated to proper landshaping and adjustment of field boundaries for consolidation of holdings, much of their alignment must remain zigzag or large portions must be excavated afresh. The cost of modification can be considerable particularly if the watercourses are lined in which case perhaps they would be left alone unsatisfactorily aligned only to come in the way of proper landshaping and adjustment of field boundaries. Nor can a network of field drains be superimposed satisfactorily in such a situation.

16.3.22 Ordinarily between a rectangular type and a contour type of layout the choice should be for the latter. The rectangular type is suitable in very even and flat terrain, but takes up more land for farm roads, drains and watercourses than the contour type. As the contour type conforms to the natural conditions more closely than the rectangular type, it entails less of change and is consequently easier and cheaper to execute.

16.3.23 In order to economise on land required for watercourses and field drains there has been a suggestion that a single channel might serve both the purposes under certain conditions. This arrangement could possibly be contemplated for fields where the general slope of the terrain is more than 2 per cent and there is appreciable drop from field to field. In such a situation the channel would act as a drain for the upper field and a watercourse for the lower one. In general the arrangement does not work satisfactorily. In most situations it is not feasible.

16.3.24 The full package of measures for land development in command area comprising consolidation of holdings, land formation provision of watercourses, field drains and farm roads would reduce to some extent the area available for cultivation. The overall gain due to the resulting improvement in the production capacity of the land on the other hand would be appreciably more. There can, however, be situations where more land becomes available for cultivation after land development has been carried out. This can arise from reclamation of waterlogged lands on provision of drainage, consolidation of small sized fields into larger ones thereby reducing the area under field boundaries, and reduction to appropriate size field bunds where too wide. Reclamation of broken or ravine land within the command of an outlet would also add to the culturable land. In order to get an idea of the increase or decrease of land in the command of an outlet due to the package of land development measures, information was sought from a number of project authorities. The information received is presented

in Appendix 16.3. It is to be noticed that the increase or decrease is not marked.

4 PREPARATION OF COMMAND AREA DEVELOPMENT REPORT

16.4.1 In Chapter 15 on Irrigation, we recommended that an irrigation project report should be prepared in three parts, besides the general report, as under :

Part I—all engineering works from source of supply up to outlets, including drains.

Part II—all engineering works in the command area comprising land levelling and shaping, construction of watercourses lined or unlined, field channels, field drains and farm roads.

Part III—all other items pertaining to agriculture, animal husbandry, forestry, fishery, communications and co-operation.

The general report and Part I have been dealt with in Chapter 15. In the present section, we deal with parts II and III which pertain to command area development.

16.4.2 Normally the Irrigation Department submits a feasibility report based on reconnaissance and preliminary surveys including agri-surveys and seeks authorisation for the preparation of project report which entails a good deal of field investigation for which funds have to be sanctioned and budgetary provisions made. Once approval of Government is accorded to the preparation of a project report, the Irrigation Department should immediately notify other concerned departments of this approval and, giving an outline of the project, advise them to take up investigations of the items which pertain to them. These concerned departments should prepare their own estimates for any field investigations which they may need to carry out and obtain the necessary sanction and funds through their own departmental channels. Generally these requirements are relatively small.

16.4.3 It is important that the responsibility for the individual items to be incorporated in the project report should be clearly specified so that no items falls between two stools. Invariably Part I of the report is prepared by the Irrigation Department. The items which go into Part II are in the nature of engineering works. Watercourses and field channels are merely water conductor system extended beyond the outlets to the fields. Similarly, field drains are extension of the drainage system in the area to individual fields and have to be properly connected to it. Construction of roads is essentially an engineering task. So is land for-

mation which in most situations require the use of earth moving machinery. In view of these considerations, the responsibility for preparing Part II of the project report is best placed on the Irrigation Department. As this work is not being handled by the Irrigation Department at present, that department should organise a special set up for the purpose. For this agricultural engineers should also be inducted in the department. The personnel should be given the necessary training. As regards Part III of the report, the departments concerned should prepare their portions and make them over to the Irrigation Department after a discussion for compilation. The Irrigation Department should then submit the complete report, comprising all the parts, for sanction.

16.4.4 Besides hydrological investigation, topographical and soil surveys are the more extensive and time consuming ones that are required for formulating an irrigation project. For purposes of Part I of the report, the Irrigation Department has to have topographical maps to a scale of 1 : 15,000. For command area development maps to a much larger scale of 1 : 2,500 are required; but they are needed for the actual execution of work and not for formulation of Part II of the report. The cost of preparing these maps should, however, be shown in Part II. For purposes of the report, soil surveys need to be carried out only to such an extent as would provide adequate information for determining suitable cropping patterns for the various parts of the command area. For actual development of command area, more intensive soil surveys would be needed at a later stage and their cost should be shown in Part II of the report.

16.4.5 In several irrigation projects, there are areas in the command which require reclamation. Normally, no provision is made for such reclamation work in Part I of the project report. This item should, therefore, be included in Part II. The extent of the area, its ownership, the nature of the reclamation work to be carried out, its cost and the mode of financing it should be fully dealt with in the report.

16.4.6 The scope of land formation in the command area depends on the nature of the terrain, the layout of the fields and the mode of irrigation. The cost would vary not only from project to project but also from area to area within the command. Unless cost figures for this work are available from an analogous area, it may be necessary to carry out actual work in some representative areas in the command on an experimental basis to arrive at a reasonably accurate figure of estimated cost for the entire command. On sanction of the project the land formation work can be executed partly by the farmers themselves and partly through either (a) land development corporation or (b) agro-industries corporation or (c) private contractors by the usual process of tendering for the work. A broad indication as to how this work would be

carried out should be given in the project report. It may be necessary to provide for some initial investment on earthmoving machinery. If so, the number and type of machines to be procured and their estimated cost should be stated in the project report.

16.4.7 In 1958, the Planning Commission recommended that the project authorities should be made responsible for the construction of watercourses at project cost. The watercourse was defined as a channel built at Government expense to convey water from an outlet to a block of 40 hectares or as may be prescribed. Beyond the watercourse the field channels were required to be built by the cultivators to serve the various fields within the blocks, the Irrigation Department assisting them by providing guidance on alignment. Most States have followed this procedure although on Tungabhadra and Nagarjunasagar projects even field channels have been constructed by the department at project cost with good result. We have already recommended in Chapter 15 on Irrigation that where lined watercourses are required to be provided these should be constructed at project cost, which should be shown in part I of the report. Field channels should be constructed by the farmers themselves but where on default these have to be constructed by the department, the cost should be recovered from the beneficiaries. While the cost of watercourses chargeable to the project is shown in Part I of the report, that recoverable from the beneficiaries should be shown in Part II. The amount would be approximate.

16.4.8 We have earlier stated that in our view farm roads should be provided by the side of field drains. The earth removed from the drain can be used to even the surface of the road. Thus the two have to be constructed together in a single operation. In Part II of the project report, the specifications of the road and the size of the field drains including underground drainage where adopted as also their costs should be stated, indicating the bases for fixing them.

16.4.9 We have drawn attention to the fact that consolidation of holdings is essential for a proper scheme of layout in the command area. The arrangements for carrying out this work as also the cost involved should be indicated in Part II of the project report.

16.4.10 As regards Part III of the projects report, the departments mainly concerned are —

(i) Agriculture Department,
(ii) Animal Husbandry Department,
(iii) Forest Department,
(iv) Fisheries Department, and
(v) Department of Cooperation.

16.4.11 The Department of Agriculture should comprehensively deal with the following matters :

(i) tillage practices, existing and proposed; manpower requirement and its adequacy; bullock power, its requirement and availability; the need and scope of mechanisation;

(ii) Cropping pattern including fodder crops, crop calendars, yield and production, both existing and on introduction of irrigation, discussing the factors which have weighed in the choice of the patterns;

(iii) requirements and production of seeds; arrangements for their distribution; suitability of different varieties for use in the area; adaptive research required for new varieties;

(iv) requirements of fertilisers and manures; arrangements for soil testing for application of fertilizers and amendments; arrangements for their procurement and distribution;

(v) plant diseases which would require attention; requirement and arrangement for supply of pesticides, weedicides and insecticides, arrangements for spraying, etc ;

(vi) role of agro-industries and the scope of their service in the command area ;

(vii) existing extension services in the command area and proposals for their future set-up ; requirement of experimental and demonstration farms ;

(viii) existing status of horticulture in the area and proposals for the future ; arrangements for nurseries and facilities to be provided to the farmers for promoting horticulture ;

(ix) arrangements for transportation, storage and marketing of agricultural produce ; and

(x) credit facilities required for the various inputs and arrangements for the same.

16.4.12 The Animal Husbandry Department should indicate the various programmes which would be taken up on the introduction of irrigation in the command area. In particular, it should deal with the requirement of livestock fodder and feeds, dairy development, arrangements for processing and marketing various products, and extension services that may be needed for the purpose.

16.4.13 The Forest Department should indicate proposals for farm forestry stating the species to be encouraged; the need of wind breaks and shelter belts; arrangement for nurseries ; and the extension organisation that may be required for promoting the programmes. In some States, canal plantation work is done by the Irrigation Department and in others by the Forest Department. Irrespective of the department that carries out canal plantation, provision for it is normally made in Part I of the report, this may continue to be so. Any scheme of irrigated

forest plantation that may be contemplated for the area would be a scheme of the Forest Department to be dealt with by that department. But it should be outlined in Part III of the report.

16.4.14 While preparing the project report, the fisheries Department has to be consulted in respect of the extent to which reservoir area should be cleared of trees and shrub, as also in respect of the structures to be provided in the interest of fishery and the minimum flows that may be required from the reservoir for riverine fishery. These matters pertain to Part I of the report. For Part III, the Fisheries Department should deal with arrangements for fishery in the reservoir, setting up of seed fish farms, the scope and proposals for tank and pond fisheries in the command area; leasing policy credit facilities; training programmes for the personnel; arrangement for marketing and processing.

16.4.15 With the prosperity which irrigation will bring to the area, there will be need for improvement in communications. More roads may have to be constructed and the existing ones improved to cope with the increased traffic. The Public Works Department or the Zila Parishad, as the case may be, should draw up proposals in respect of these requirements for incorporation in Part III of the report.

16.4.16 The Department of Cooperation should deal with marketing, processing, supply of credit and provision of storage on a cooperative basis.

16.4.17 We would like to clarify that whereas Parts I and II of the project report are intended to be operative on sanction of the project, Part III is intended to bring home to the sanctioning authority the scope of the developmental programmes which will need to be initiated and carried out in other connected fields. The concerned departments will prepare their detailed schemes in due course and obtain sanction through departmental channels in the normal way. Part III of the report would serve to focus attention on these programmes so that none is overlooked and also ensure proper coordination from point of timing.

16.4.18 There can be a genuine apprehension that the preparation of Part III of the project report involving a number of departments, as it does, may be delayed by one department or the other, and that may hold up the submission of the entire project report for sanction. As the main task of preparing the project report has to be shouldered by the Irrigation Department, that Department should indicate the date by which Part I and II would be ready and should intimate to the other concerned departments the date by which their part of the report should be made available. It should then keep in touch with the progress made by them in the matter, requesting them for expedition where it lags.

16.4.19 In 1954, the Planning Commission issued for the guidance

of project authorities a memorandum on investigation of irrigation projects and indicated how project reports were to be prepared. The concept of an irrigation project was then confined to engineering works only. These guidelines were later modified in 1961 and a modified memorandum was circulated by the Planning Commission. The memorandum envisaged construction of watercourses as part of the project, but the general concept remained unchanged. Since then, there has been a growing awareness that an irrigation project does not merely consist of works designed to supply irrigation water but also encompasses all connected measures for proper utilisation of water. Command area development thus formed an important part of the project and future irrigation project reports were required to provide for it. In view of this, in March 1974, the Planning Commission issued fresh guidelines for the preparation of project reports and prescribed a format for the same. We suggest that the format should be modified in the light of the suggestions and recommendations contained in this and the preceding chapter.

5 PERSPECTIVE OF COMMAND AREA DEVELOPMENT

16.5.1 As explained earlier in this chapter, measures for command area development comprise (a) land formation as may be dealt with in Part II of project report and (b) all other items of development which may be set out in Part III of the report. But land formation with well laid out watercourses, field channels drains and farm roads is the very foundation on which the success of other measures and increased production rests. This highlights the importance of timely and proper implementation of land formation programmes. Even on completion of land formation work in a command area it takes some time for farmers to make the fullest use of irrigation supplies particularly where there is no previous experience of irrigated crop husbandry. The farmers have to muster resources in money, bullock or machine power, and cautiously familiarise themselves with the techniques of irrigated crop husbandry. In drawing up a perspective of command area development, it would perhaps suffice to consider the magnitude and pace of land formation work in time sequence. Other measures would follow with some lag.

16.5.2 For land formation in command area the following steps have to be taken and a sequence of operations observed :

(i) preparation or updating of land maps ;
(ii) updating of land records ;
(iii) soil survey and collection of other relevant data ;
(iv) motivating farmers and obtaining their consent to land

formation programme ;

(v) preparation of layout plans and designs ;

(vi) consolidation of holdings ;

(vii) procurement of machinery ;

(viii) obtaining advance loan from bank in the form of interim accommodation for six months on the basis of plans prepared ;

(ix) obtaining and forwarding applications from individual farmers to the bank for processing ;

(x) actual carrying out of land formation work; and

(xi) sanction of loan to the farmers by the bank and its adjustment against the advance made to the land development corporation.

A number of these operations can be taken up simultaneously and, therefore, it should be possible to complete the task in two to three years from the time it is taken up, depending upon the state of land records and availability of maps. It would be necessary to modify the consolidation procedures to speed up the process. Also, if an undue lag in the utilisation of irrigation supplies is to be avoided, then it is necessary to take up land formation work in hand concurrently with the construction of irrigation channels.

16.5.3 There is a considerable backlog in command area development in the existing major and medium irrigation projects. At present, command area awaiting land formation work is of the order of 10 Mha including that where irrigation supplies would become available in the next two to three years and which ought to be tackled now. Land formation work would need to be completed in about 30 Mha by the year 2000 and in about 49 Mha by the year 2025. Table 16.1 gives the phasing of the land preparation work to be done. Of course some of the land may not require any significant land grading or land shaping, but every command area would require most of the items of work necessary for getting it ready for irrigation.

TABLE 16.1

Programme of Land Preparation under Major and Medium Irrigation Projects

(million hectares)

Year	Cumulative net area requiring land preparation	Area remaining to be prepared	Annual rate of land preparation	Prepared during the previous five-year period	Backlog
1	2	3	4	5	6
1975 . .	10	10	Neg.	..	10
1980 . .	13	13	1.0	2.0	11
1985 . .	17	15	1.4	6.0	9

1	2	3	4	5	6
1990 . .	21	13	1.4	7.0	6
1995 . .	25	10	1.4	7.0	3
2000 . .	30	8	1.4	7.0	1
2005 . .	35	6	1.0	6.0	..
2010 . .	40	5	1.0	5.0	..
2015 . .	44	4	0.8	4.0	..
2020 . .	47	3	0.6	3.0	..
2025 . .	49	2	0.4	2.0	..

16.5.4 Land formation work is being carried out by a number of command area development authorities on different projects. But the pace is exceedingly slow. With a backlog of 10 Mha, all that could be achieved by these authorities in the last couple of years is about a lakh of hectares with most of it only partially done. The Union Government has set before it a target of adding an irrigation potential of 5 Mha in the remaining four years of Fifth Plan. Stepping up from the present insignificant pace to one Mha per annum by the year 1980 would require a stupendous effort and this requires immediate action. Even so, during the Fifth Plan period it may be possible to develop only a couple of million hectares. The constraints would be both organisational and financial. We have dealt with these later on in this chapter. Even with a conservative figure of three million hectares of additional potential in the last four years of the Fifth Plan, the backlog of land formation work would be more by the end of the period. Stepping up of the tempo of work in subsequent period can gradually reduce this backlog leaving a small one by the turn of the century. We cannot urge too strongly that the problems of command area development, particularly those pertaining to organisation and finance should be given immediate and serious attention. The requirement of funds for this programme, mostly from institutional sources, is expected to rise to Rs. 120—150 crores per annum by 1980, and increase further as the pace of development gets stepped up.

16.5.5 Proper land formation is equally important in the commands of minor irrigation projects, though individually on a much smaller scale. Most of the groundwater development is concentrated in the alluvial tracts. Here the terrain is generally even and land formation is relatively easy though no less important. Where the terrain is uneven land formation should receive due attention. By the turn of the century there would be about 9 Mha that would require action. In the case of groundwater, the sinking of tubewell and its command area

development should be a single composite work to be carried out simultaneously.

16.5.6 Not on all existing irrigation projects the best use of irrigation supplies is being made. In our Interim Report on Modernising Irrigation Systems and Integrated Development of Command Areas we recommended that the existing projects should be reviewed with a view to improving them for more efficient performance and better use of irrigation supplies. This review should include an examination of command areas to bring out the work that would be necessary in the matter of their development on the recommended lines. This requirement has to be kept in view in making the organisational and financial arrangements.

6 ORGANISATION

16.6.1 For a satisfactory development of command areas there has to be an adequate and efficient organisation to implement the programme. As the concept of command area development has been undergoing a transformation from the earlier idea of merely providing watercourses and field channels and later also field drains to the present comprehensive concept of complete land development and provision of infrastructure and inputs, so have the organisational arrangements been changing to implement it. In the fifties, Tungabhadra Project was one of the earliest major projects to provide irrigation in an area where land was undulating, the soil difficult to cultivate and the farmers unfamiliar with irrigated farming. There it was soon realised that without governmental assistance and guidance in a big way, the area would take a long time to develop. The Divisional Commissioner was therefore concurrently appointed as an Administrator to supervise and coordinate the activities of the concerned departments in this developmental effort. Later, a similar step was taken for the Kosi command area in Bihar.

16.6.2 It was, however, realised before long that something more than mere coordination of efforts of the various departments was required for the expeditious and proper development of the command areas. On the Nagarjunasagar Project in Andhra Pradesh, therefore, a different setup was adopted. A senior engineer was appointed Special Secretary in the Irrigation Department and he headed the Development Committee of the Project. He was given the powers of head of the department of all the departments involved in the development of the area. Under him a team of officers of four departments, namely, Irrigation, Revenue, Cooperation and Agriculture was formed. This field

team visited the area, village by village, and jointly sorted out the problems of the farmers regarding irrigation supplies, location of water-courses, adoption of cropping patterns for irrigated farming, supply of inputs, etc. Arrangements were also made for some landlevelling though not comprehensively. In 1968, a Member Board of Revenue was put in charge of the development.

16.6.3 At the beginning of the Fourth Plan, ten major projects were selected for intensified effort in the full and proper utilisation of irrigation supplies. Four more projects were added later on. It was envisaged that in the command areas of these projects, the State Governments would take up the work of soil surveys, construction of water-courses and field channels to the extent necessary and also some field drains. These areas were to be brought under the Area Development Programme for the development of infrastructure like roads, markets, storages, etc. Even at that stage, practically no separate organisation was set up for carrying out these activities, which remained mostly individual efforts of the concerned departments which were sought to be coordinated by appointing a senior officer for the purpose in the project area.

Command Area Development Authority

16.6.4 In spite of the efforts for a coordinated and concerted programme of action by the various departments in command area development, the progress continued to be tardy in making good use of the irrigation facilities for a rapid increase in agricultural production so urgently needed. The Central Government, therefore, suggested to the State Governments in 1973, that they should create by an executive order a Command Area Development Authority (CADA) for each command with an Administrator at the head of each. Such an Authority could have more than one irrigation command if the size be not large enough. The Administrator was to be given the powers of head of the department for all the concerned departments and a separate budget head in the State budget was to be created for each command area. At the State level, it was suggested that there should be an inter-departmental committee under the chairmanship of the Chief Minister to keep under constant review problems relating to the optimum utilisation of irrigation. Also a wholetime secretary to be designated as Secretary, Water Utilisation and Command Area Development, having the status of Additional Agricultural Production Commissioner was to be appointed. This wholetime Secretary was to be ex-officio Secretary in the Agriculture, Revenue, Cooperation, Forests, PWD, Irrigation, Planning and Finance Departments in respect of the command areas. This was a drastic change in the normal governmental setup and

reflected a deep anxiety on the part of the Centre to secure very speedy development of command areas. Guidelines for the functions, constitution and powers of Command Area Development Authorities were supplied to the State Governments.

16.6.5 The Union Government indicated its readiness to share with the States, on a 50 : 50 basis, the cost of establishment of CADA and the constitution of Water Utilisation and Command Area Development Department at State level, as also for soil surveys, preparation of farm plans, supervision, etc. Equity capital support to land development corporation, farmers' service societies, etc. for providing institutional finance to farmers for construction of field channels, field drains, land levelling and land shaping was also to be shared on that basis. The States got busy in implementing the suggestions of the Centre regarding the setting up of the CADA. In the Fifth Plan, 51 irrigation projects including 14 previously selected have been proposed to be brought under CADA in 16 States. By April 1975, CADA had been created for 31 of them. The pattern of these authorities, however, is not uniform. Their composition and responsibilities vary from State to State and some are described, illustratively, in the following paragraphs.

16.6.6 In Maharashtra, a comprehensive organisation has been created for command area development. In the Secretariat, a separate Secretary has been appointed in the Irrigation Department to deal with it. The organisation has three tiers. There are five Command Area Development Authorities covering 11 projects. At the apex, each Authority has a Board with a Minister as its President and 29 to 45 members comprising one to three Ministers, some Members of Parliament and Members of Legislative Assembly and other public men, the Command Area Development Commissioner, the Divisional Commissioner, the concerned Collectors and senior technical officers etc. The Board approves the annual programmes, reviews its implementation and effects coordination between the different departments and development agencies. Once a programme and a plan of action are approved by the CADA, it becomes binding on all the departments concerned. The Board has full powers to take all decisions pertaining to the development of the command areas subject to the general policy directions of the Government, and the financial provisions made in the plan and budget. At the next level, each Command Area Development Authority has an Executive Committee headed by a Chairman who is its chief executive. He is of Commissioner's grade and exercises all powers of head of the departments concerned. The Commissioner of the Division, the Administrator of the Command Area Development Authority, technical officers of Superintending Engineer or equivalent grade and some non-officials are its members. The Executive Committee takes

decisions on routine day-to-day matters. In the third tier of the organisational set up is the Administrator. There is one for each Command Area Development Authority. He is a full time officer who is subject to the control of the Board and the Chairman of the Executive Committee. He is responsible for implementing the policies and programmes formulated by the Board or the Executive Committee. The Administrator is also Vice-Chairman of the Executive Committee. He has all the administrative and financial powers which are exercised by the Collectors of the districts and the regional officers of the various concerned departments. He can be an Administrative Service officer or a technical officer. The functions of the Command Area Development Authorities are very comprehensive. In fact they go beyond what they need be. The constitution and functions of these authorities are given in Appendix 16.4.

16.6.7 The Gujarat State has set up only two Command Area Development Authorities, one each for the Ukai-Kakrapara and the Mahi-Kadana Command Areas. Each Authority is headed by an Area Development Commissioner and has as its members the Development Commissioner of the State, heads of the departments concerned, District Development Officers and Collectors of the districts concerned, representatives of certain banks etc. The functions of these Authorities are similar to those in Maharashtra but less comprehensive. Under this arrangement all executive powers of the Authority vest in the Area Development Commissioner who is a full-time officer of the rank of Secretary to the Government. He exercises within his jurisdiction all powers of a head of a department. The composition and functions of these authorities are shown in Appendix 16.5.

16.6.8 In Bihar, the State Government has set up three Command Area Development Authorities, one each for Kosi, Gandak and Sone Projects. These Authorities are responsible for water utilisation and integrated area development in the irrigation command of the respective project. Each Authority has a Board with the Command Area Development Commissioner as its Chairman and senior officials of the departments concerned, as also some non-officials, as its members. The Command Area Development Commissioner acts as the chief executive officer of the Authority. He exercises administrative and disciplinary control over all the staff of the concerned disciplines such as agriculture, irrigation, cooperation, soil conservation, animal husbandry, fisheries etc. employed in the command area. There is provision for a separate budget head for command area development.

16.6.9 In Uttar Pradesh, for the Gandak Project, Government has set up the Gandak Area Management Board with the Divisional Commissioner as its Chairman, the Project Commissioner as its Vice-Chairman and the Secretaries and heads of the concerned development

departments as members besides two non-official members. The Area Development Commissioner has been given the powers of head of a department of all the departments concerned. It is to be noticed that the organisation for command area development of Gandak Project is less elaborate than that in Maharashtra and Gujarat.

16.6.10 In Haryana, a Command Area Development Authority for four none too large irrigation projects is envisaged as a registered society under the Registration of Societies Act. The Divisional Commissioner, Hissar is to be the Chairman of the society. Other members are senior officials of the departments concerned. The Divisional Commissioner, as Chairman of the society, will be an ex-officio Secretary to Government in CADA Department to be created. The development schemes in the command areas are to be implemented by the departments concerned. At the project level, the coordination between the various departments is to be done by the Additional Deputy Commissioner as ex-officio Chief Project Officer, and at the level of CADA by the Divisional Commissioner. At the State level for guiding the Command Area Development Authority, there is to be a State Level Committee with the Chief Secretary or Financial Commissioner as Chairman, and Secretaries of all the departments concerned as members. This State Level Committee would take decisions on behalf of the Government referring such matters to the Council of Ministers as it may consider necessary at its discretion.

16.6.11 The pattern of organisation for command area development that is being created in the States was evolved under the compulsion of speedily remedying the ills which had arisen due to inadequate and improper use of irrigation supplies. There was a considerable gap between the irrigation potential created and its utilisation. Not only the large investment made on these projects were not proving productive enough but the land in the command areas of some of them was also getting damaged due to wasteful use of water. The first attempt, therefore, was to tackle the projects which had good potential but were developing very tardily or erratically. An organisation thought to be effective was devised for developing each of the more important of these projects. Later, the concept was extended to new projects as they materialised. In evolving the pattern of organisation for command area development, the influence of the financing organisations like the IDA was not insignificant. From their point of view it is convenient to bring under one umbrella the various activities for which money is advanced. The organisation devised for command area development, first conceived on an emergency basis, cuts across the established departmental hierarchy and was intended to cut short delays in the day-to-day work and ensure better coordination between the departments engaged in this work. It is, however, a matter for examination and consideration

whether these organisational arrangements evolved for a few projects are suitable for adoption on a long term basis.

16.6.12 Since Independence 97 major and 513 medium irrigation projects were taken up for construction up to the end of Fourth Plan. During this period, 22 major and 358 medium projects were completed. These together had an irrigation potential of 11.4 Mha. In a number of these projects, particularly the ones which were taken up early in the plans, irrigation has developed and not much more is required to be done except by way of normal extension work. Then there are projects which are only partially developed and which still require some land formation to be done and field channels, field drains etc. to be provided. The more recent projects and those under construction require the full package of developmental work. It has been estimated that about 10 Mha of command area now requires preparation for proper irrigation including that for which irrigation supplies will be available in the next two or three years. By the year 2000 another 20 Mha will have been added to it. To deal with this large area of 30 Mha, it would be necessary to have an organisation capable of handling on an average about one Mha per annum by 1980 and 1.4 Mha by 1985. This is indeed a big task and requires an efficient, steady and streamlined organisation manned by competent technical personnel well rooted for a continued employment on tasks requiring their expertise. So far, in the projects for which Command Area Development Authorities have been set up not even one per cent of the overall tempo required to keep pace with the potential has been built up.

16.6.13 The extent of the area requiring land development would vary from State to State. In a number of States there is already a heavy backlog. However, it is in ten States where most of the command area requiring action will lie. Table 16.2 gives statewise figures.

TABLE 16.2

Area Requiring Land Preparation Under Major and Medium Projects

(million hectares)

State	Immediately	Total up to 2000 A.D.
1	2	3
Andhra Pradesh	1 5	3.0
Bihar	1.4	4.0
Gujarat	0.7	2.4
Karnataka	0.9	2.0
Madhya Pradesh	0.7	2.5
Maharashtra	0 3	2.2
Orissa	0 3	1.9

1	2	3
Rajasthan	0.7	2.3
Uttar Pradesh	1.8	4.5
West Bengal	0.6	2.0
All other States & Union Territories	1.1	3.2
Total All-India	10.0	30.0

It is to be noticed that in the ten States listed above, the area to be dealt with upto 2000 AD varies from 2 Mha to 4.5 Mha. In the rest of the States and Union Territories it varies from about 1 Mha to a negligible amount. The size and nature of the organisation to cope with the area may thus also vary from State to State. But it is necessary to evolve a broad approach which the various States may find suitable for adoption on a long term basis.

16.6.14 In the prescribed set up of Command Area Development Authority, the Administrator functions as head of a department of all the concerned departments within his jurisdiction. The technical staff working under him receive their instructions and orders from him and not from their departmental superiors. In several States, he writes, the annual character rolls of Class I officers of technical departments under him and, therefore, it is he who commands the loyalty of these officers and not their departmental superiors. Being thus detached from the departmental mainstream the technical personnel deal with the various technical problems on their own with little guidance from the departmental superiors who view them with some indifference as belonging to another organisation. With a separate budgetary provision for each command area and with powers vested in the Administrator to make inter-disciplinary adjustments, the Command Area Development Authority more or less takes the shape of a miniature government except for law and order. It is burdened with numerous responsibilities. The Maharashtra pattern stipulates twenty two functions as may be seen in Appendix 16.4.

16.6.15 As more and more area is brought under Command Area Development Authorities in a State, the departmental jurisdiction there shrinks. This process, by the turn of the century would put nearly a third to a half of the total area in some States under the authorities unless some of these are abolished in the meantime. In such States, the concerned developmental departments will have suffered a severe setback and their normal pattern of administration disrupted. It does, therefore, appear that the arrangement for command area development through Command Area Development Authorities, expedient though as a short term measure may not be quite suitable as a pattern for the future.

16.6.16 In Chapter 62 on Administration, we have stressed the need of maintaining a single line of command from the top to the field level so that responsibility for action is not diffused. The need of coordinated and concerted action in developmental work is, however, recognised. For this reason, we have recommended that at the State level there should be an Agricultural Production Commissioner and at the district level a Chief Agricultural Development Officer (CADO). The main functions of CADO are to be to secure coordination between extension services, supply of inputs, credit and marketing and to provide appropriate agri-support activities. The departments that he would be directly concerned with are Agriculture, Animal Husbandry, Community Development or Rural Development, Minor Irrigation, Fisheries, Farm Forestry and Cooperation. He would also liaise with other development departments such as Irrigation, PWD, and Electricity, and with *panchayati raj* institutions and other autonomous bodies, private organisations and institutions in the field of agriculture.

16.6.17 In a district having some canal irrigation, there would be command area, some area irrigated with groundwater and a considerable rainfed area. The proportion of command area and the rest would vary from district to district. If the command area in the district is to be administered for development purposes by a Command Area Development Authority and the rest is to be under the plurview of CADO, this in itself will create a problem of coordination in planning, progress reporting, evaluation, supply and distribution of inputs and extension work for the district as a whole. It would, therefore, appear desirable that CADO should have jurisdiction over the entire district including the command area where there is any.

16.6.18 In a command area the development work can be classified under two categories, namely, (a) formation of land to make proper use of the irrigation supplies on their becoming available, and (b) inputs, services and extension work. The first category is a one-time job and on its completion the organisation doing the work is replaced by that required for maintenance. The measures under the second category are of a continuing nature and require a regular continuing arrangement comprising governmental and institutional agencies. If the two categories are to be under the same ambit, it can only be for as long as the work under the first one lasts. While the inputs, services and extension work can be satisfactorily handled by the normal departmental or institutional set up, the task of land formation requires a specialised organisation that can be brought in for the purpose and which then moves on to another command area when one task is completed. In most States such an organisation will need to be a sizeable one, more or less comparable to that required for the construction of irrigation projects. Unlike construction work on projects which are

concentrated in particular locations or in narrow strips, the work of land preparation in command areas is widely spread out and entails contact with large number of people. It is tedious and requires a very efficient and strong organisation.

16.6.19 In Section 3 of this chapter we have set down the items of work that have to be carried out for land development in command area. Land grading and shaping, and construction of watercourses, field channels, drains and farm roads are tasks which require a degree of engineering skill. In most cases earth moving machines have to be used for land formation and these are best operated and maintained by engineering personnel. It is of utmost importance that land grading and construction of watercourses are done in a precise relation to the position of outlets and the level of water there. Again, field drains must be constructed at a level that would ensure smooth flow of water to the connecting drain and on to the main drain. In fact, watercourses and field channels are merely extensions of distributaries and minors, and field drains that of the drainage system to individual fields. Furthermore, the programme of land development has to be carefully coordinated with that of construction of distributaries and minors. Whenever there is change in the target dates of construction, which frequently happens, it would necessitate a corresponding change in the programme of land development. From the above considerations it would be desirable that the work of land development should be placed under the purview of the same department as is responsible for the construction of irrigation works, namely, the Irrigation Department.

Land Development Corporation

16.6.20 In the land development operation in a command area, it is the land formation which is the more expensive part of the work. Different holdings may require grading and shaping to different extent. It may be stated that in a command area the farmers may themselves do this work in part of the area and require assistance for the rest. Each farmer incurs a liability commensurate with the amount of work which may be done on his holding. In most cases he has to take a loan from an institutional source to defray the expenditure incurred on his holding. We have dealt with the financial arrangements for command area development further on in this chapter. Suffice it to say that because financial institutions have to provide bulk of the amount required for land development, the organisation has to be such as can avail of that source. For this reason, the land development work is best entrusted to a Land Development Corporation and not to a government department. The Corporation should be invested with the necessary authority to adequately discharge its functions. To begin

with it should borrow technical and skilled personnel particularly for its top echelon from the Irrigation, Agriculture and other departments making also direct recruitment. Gradually it should have mostly its own staff. Agricultural and other engineers which it may recruit should be put through a course of training to specialise for the work. At the secretariat level the Corporation should be the responsibility of the Irrigation Department.

16.6.21 The Land Development Corporation will need to have its own fleet of earthwork machines. The size of the fleet will depend on its workload on a continuing basis. It should also have a well equipped central workshop for major repairs to the machines and field workshops for maintenance and repairs in the field. With regular skilled personnel employed for operating the machines, an expertise would get built up for land development work. The complete set up comprising men and machines can go from one job to another. This arrangement will be much more satisfactory than what individual Command Area Development Authorities can have as pooling of machine resources by them in a State would present difficulties.

16.6.22 On some of the projects where command area authorities have been set up, the state soil conservation organisation has been entrusted with the work of land preparation and special training given to the personnel engaged in this work. This organisation had originally been set up for taking measures for soil and moisture conservation in rainfed areas and that should remain its main task.

16.6.23 In several States, the agro-industries corporations have some earthmoving equipment which is intended for custom service. These corporations have several functions and earthmoving can be but only one. Land grading and shaping in command areas is such a job as requires the fullest attention. The work has to be done along with the construction of watercourses, field channels, field drains and farm roads as a single operation. For all this the agro-industries corporation would not be the best agency.

16.6.24 In Section 3, we have already emphasised that consolidation of holdings is essential for a proper layout of watercourses, field drains, farm roads and the fields themselves. Since the work of consolidation of holdings is inseparable from the preparation of a proper layout plan, the main burden of consolidation work has to fall on the Land Development Corporation. The Corporation should have at its disposal special staff for the purpose either borrowed from the Revenue Department or specially trained for the purpose. These have to be people who are good at public relations and are persuasive enough to carry conviction with the large number of farmers regarding the benefit of command area development, of which consolidation of land-holdings is an important element. There should be a legal provision

that once it is declared that in a command area land formation operations are to be taken up, consolidation of landholdings should become obligatory. In carrying out this work, while it should be permissible to enforce consolidation of holdings, an attempt should be made to carry public opinion with it. Farmers' committees or associations set up in the villages can help a great deal in resolving most of the disagreements which might be amongst the landholders in respect of consolidation of holdings. After the consolidation of holdings is finalised by the Land Development Corporation, the papers should be handed over to the Revenue Department for legalising the adjustments. It would be a satisfactory arrangement if a revenue official dealing with consolidation of holdings is attached to the Corporation for the duration of the land development operations. Consolidation of holdings can get delayed if the revenue record of landholdings is not uptodate. In such cases, it would be advisable to deploy special revenue staff well in advance of the land development activities so that the record is brought uptodate before the work starts.

16.6.25 When the Land Development Corporation is engaged in land formation in any part of a command area, there is considerable dislocation in the normal farming activities there. During this period, which may be two to three years, interim cropping patterns may have to be adopted and special arrangements made for the supply of seeds and other inputs. Also the altered farming activities have to be coordinated with the programme of land formation, which in turn has to be in step with the construction programme of irrigation works. The problems which thus emerge require concentrated attention, which the normal organisation in the district may not be able to give adequately. It is, therefore, important that during this transition period, a senior technical officer should be placed in overall charge of the various activities. He can be named Project Development Officer and should have adequate supporting staff. As soon as the land development operation in any block in the command area is completed, the block should revert to the normal organisational arrangements in the district, each department attending to the functions that pertain to it and the various activities coordinated at the district level by CADO.

Preparation of Maps

16.6.26 Earlier in Section 3, we have expressed the view that available village maps not being accurate enough for purposes of land formation, fresh maps have to be prepared in most cases. For keeping pace with the command area development programme, maps of an area of about a million hectares will need to be prepared every year. In fact, allowing for extra peripheral area that would be required to

be mapped, the task would be even larger. Considering the magnitude of land preparation work, the most sophisticated techniques of mapping will need to be adopted from consideration of speed of work, accuracy and cost. Aerial photography would be a major element in this task. Hitherto the work of preparing maps for command area has mostly been entrusted to the Survey of India. The Survey of India in turn has been getting aerial photographs taken by a private company located at Calcutta. The company has its own planes. It has been supplied with a special camera by the Survey of India and is able to photograph about 4 Mha in a working season of 130 to 150 days from October to March. In the remaining period of the year, it utilises its planes for geomagnetic work, spraying pesticides and for purposes of dropping supplies in the north-east region. Another company located at Bombay, does not at present do aerial photography and is mostly engaged in agricultural spraying. Given a camera this company can also carry out aerial photography. There is, thus, adequate potential available in the country for carrying out aerial photography for preparing maps for command area development. The present capacity for preparing maps by photogramatic process however is limited to about 50,000 hectares per annum. This will need to be augmented.

16.6.27 If the work of command area development is to progress smoothly and uninterruptedly, then there must be a steady supply of maps for the purpose. Although the Survey of India has been preparing maps for many command areas in the past, yet this has not been its main responsibility. Apart from its normal work, it gets entrusted with priority tasks for Defence Department and for priority exploratory work. Whenever it undertakes these urgent assignments, other work tends to slip. In view of this and considering the large mapping programme which will have to be undertaken for command area development, it would seem advisable to have a separate Land Survey and Mapping Corporation for the purpose under the same Ministry as administers the Survey of India. This Corporation can initially draw some of the required personnel from the Survey of India and Indian Photo-Interpretation Institute, Dehra Dun, which have the requisite expertise in the matter. Alternatively a separate wing may be created in the Survey of India itself for the purpose and might be called the Command Area Mapping Wing. It might be pointed out that the air survey companies only provide aerial photographs. The rest of the steps required for producing finished maps have hitherto been taken by the Survey of India. The Land Survey and Mapping Corporation or the Command Area Mapping Wing, when set up, would also arrange for ground control work and detailed levelling which are necessary for preparing accurate contour maps from aerial photographs.

16.6.28 For command area development, it would not be necessary to have printed maps to work on. These maps are required only for the purpose of preparing the layout for land development. After this development has taken place, the maps would be completely out of date. Therefore, it would be sufficient to have a few copies of azoprints made from maps drawn on transparent paper. These maps would be useful in preparing revised village maps which for purposes of field use are normally drawn on cloth sheet. With this arrangement, the cost of printing maps which is substantial will be avoided.

16.6.29 Aerial photographs and most of the maps are at present treated as restricted material for security reasons and as such are not available freely even to government departments for planning developmental work. This has been hampering progress. In 1971 and 1972, this matter was taken up by the Planning Commission with the Survey of India and the Defence Department on behalf of other development departments which normally require these maps, but so far no tangible results have emerged from these discussions. If the developmental work is not to be unduly hampered, then it is necessary that these restrictions should be relaxed to the maximum extent feasible.

16.6.30 In Section 4 of this chapter we have emphasised that simultaneously with the investigation of an irrigation project, investigations should be started in other fields of development in the command area of the project, such as agriculture, animal husbandry, fisheries, etc. In order that the preparation of the project report is not delayed, it would appear necessary to have a planning cell in each of the concerned departments at the State headquarters, which would devote sustained attention to formulation of proposals in respect of command areas.

16.6.31 On some of the projects it may be found that because of sparse population, there is not enough manpower to meet the requirements of irrigated farming in the command area. As indicated in paragraph 16.4.11, the Department of Agriculture will have made an assessment of manpower requirements and its adequacy. Where the situation reveals that more people have to be brought in from outside and settled in the command area, a proper organisation for the purpose under the Revenue Department should be set up. The settlement of these people should be planned well in advance and coordinated with the programme of command area development.

7 ECONOMICS AND FINANCING

16.7.1 For command area development there are four sources of finance depending upon the nature of requirement. These are :

Central Government, State Governments, institutional agencies and farmers' own resources. The assistance from the Central and State Governments is in the form of subsidies for approved programmes to certain categories of farmers such as small and marginal farmers, as also for certain specific items of development. In the Fourth Plan provision was made in the Central sector for the development of markets, storage facilities and communications in the command areas of some large irrigation projects. But it is the developmental requirements in the command of an outlet and his own agricultural needs which are of personal concern to a farmer. For these he has to look to institutional sources of finance.

Credit to Farmers

16.7.2 The farmer requires credit for a variety of purposes ; a long term credit for land development, farm mechanisation, and private exploitation of groundwater for supplementing canal supplies where necessary and feasible ; medium term loans for purchasing additional drought animals for intensive irrigated cropping and for any subsidiary occupation such as poultry farming, animal husbandry, fisheries, etc., and short term loans for quality seeds, fertilisers and pesticides. Altogether these requirements add up to a sizable amount. In undertaking to make an investment on any of these items, the farmer has to feel fully convinced of its worthwhileness. He has to make sure not only that the return from the investment would enable him to liquidate the loan within the stipulated period but would also give him some immediate benefit. Only then he would be motivated to invest.

16.7.3 We have dealt with in an earlier section the various elements of land development in a command area. Three distinct categories of expenditure can be identified in developing the area commanded by an outlet. There, expenditure on a certain length of watercourses is chargeable to the irrigation project and, therefore, does not impose a burden on the farmer. All other items of land development excluding land grading and smoothening can be classed as common facilities and the expenditure on them shared by the farmers on *pro rata* basis. It is land grading and smoothening where the cost per hectare would vary from holding to holding which would concern individual farmer. This element of cost would be subjected to the most careful scrutiny by him. Any proposal in this respect would need to carry conviction with him as to its worthwhileness. In preparing the layout plan for the development of an area commanded by an outlet, therefore, the economics of the various items should be

carefully considered. Some of the items are obligatory and have to be carried out. For example, watercourses and field channels must be provided if the fields are to be irrigated. But there are items for which justification has to be given. For instance, in a low rainfall area the need for field drains can be debatable. Again if the land slope in a holding is excessive, it becomes a matter for consideration whether to make a heavy investment in grading it to a reasonable slope or exclude it from the irrigable area.

16.7.4 Although the necessity of proper development of land in command area is generally accepted, in actual practice this requirement has remained neglected. Among the reasons for this neglect might be mentioned the paucity of technical knowhow, an incomplete understanding of the economic benefit of land formation and lack of financial resources with the farmers for undertaking the task which required considerable effort or investment. The farmer fully understands the need for even spread of irrigation water on his field but is not fully aware of the extent of benefit that accrues from it. Proper levelling of land can save 15 to 20 per cent of water which can be utilised for irrigating more area. Also it enables excessive rain or irrigation water being drained out without causing soil erosion. In the absence of land levelling irrigation water is misused through excessive irrigation or uneven spread on the field. That may lead to waterlogging or salinity problems and an uneven stand of the crop with consequent low yield.

Pilot Studies in Water Management

16.7.5 In order to evaluate and demonstrate the benefits of efficient water management techniques involving land levelling, the Ministry of Agriculture[1] undertook more than a score of pilot projects in the commands of some of the major and medium projects in a number of States. The preliminary data obtained in the last few years from the projects in operation at Bellary in Karnataka, Dohrighat in Uttar Pradesh, Patiala in Punjab and more recently Tawa Project in Madhya Pradesh have been analysed with a view to ascertaining the economics of land formation under different soil and land conditions. In each project, the land formation operation was carried out on a number of holdings and an average figure obtained. The results, given in Table 16.3, though not definitive are indicative enough beyond doubt that in most situations land formation confers considerable economic benefit.

1 Now Ministry of Agriculture and Irrigation.

TABLE 16.3

Benefit Cost Ratio of Land Formation Work in Selected Command Areas[1]

State	Location	Type of soil	Slope per cent		Average cost per ha (Rs.)	BC Ratio	Year
			initial	final			
Karnataka	Bellary	black cotton	1.0	0.1	769	1.0 to 1.0	1971
Uttar Pradesh	Dohrighat	alluvial	0.6	0.0	182	4.5 to 1.0	1972-73
Madhya Pradesh	Tawa Project Sawalkheda	black	0.9	0.2	2,134	3.5 to 1.0	1972-73
	Risalpur		1.0	0.2	1,956	3.2 to 1.0	
Punjab	Patiala	alluvial					1970-71
			0.5	0.1	308	4.0 to 1.0	
			1.0	0.1	519	3.4 to 1.0	
			1.5	0.1	718	3.0 to 1.0	
			1.0	0.2	471	3.5 to 1.0	
			2 0	0.2	873	2.8 to 1.0	
			3.0	0.2	1,276	2.3 to 1.0	
			6 0	0 3	2,447	4.9 to 1.0	
			9.0	0.3	3,657	3.7 to 1.0	

1 Pillai P. N. B and Rege N. D — 1974 — Economics of Land Levelling in Irrigation Commands—A Preliminary Study, Water Management Division, Ministry of Agriculture and Irrigation, New Delhi.

16.7.6 The cost of land formation, as Table 16.3 reveals, is not directly proportional to the slope of land. It depends on several other factors such as the type of soil, the undulating nature of the land, field sizes, the type and efficiency of machinery and equipment used and above all the experience and efficiency of the persons carrying out the work. Where the soils are easy to move such as alluvial soils and slopes are none too steep thereby requiring less amount of work, it may be within the capacity of an individual farmer to himself carry out land formation of his holding or part of it. This should be encouraged provided he conforms to the layout plan and design prepared for the command of the outlet.

16.7.7 We have suggested earlier in this chapter that the entire work of land development in a command area should be entrusted to Land Development Corporation to be set up for the purpose. The Corporation would carry out the work on behalf and at the cost of the farmers, allowing for any subsidy which the Centre or State may give for the purpose. The Corporation thus has to have some funds of its own for equipping itself with the necessary equipment and machinery and for meeting the organisational expenses. For dealing with one lakh hectares per annum its share capital may be of the order of Rs. 2 crores and its working capital Rs. 5 to 8 crores. The funds for carrying out the work have to come from institutional sources as long term loans to individual farmers passed on to the Corporation for the purpose.

Financing by Farmers' Service Societies

16.7.8 The financial institutions from which a farmer may secure credit are a primary cooperative credit society, a multipurpose cooperative society, a farmers' service society (FSS), a primary cooperative land development bank, a branch of state land development bank or a branch of a commercial bank. The farmers' service societies are being set up to provide integrated agricultural credit service primarily to the small and marginal farmers and agricultural labourers. Considering its relatively meagre resources the FSS will need to be provided with sufficient credit to enable them to cater also to the requirements of the farmers for land development in command areas. The role of cooperative banks in the agricultural sphere has been confined to providing short and medium term credits and it would be beyond their capacity to cope with the long term requirements of land development. The commercial banks have taken increasing interest in the agricultural sector since nationalisation of major banks. They have been providing both short term and long term loans to

farmers. The banking system, especially the commercial banks, have been keen to ensure that both the long and short term credits are provided to an individual farmer by one and the same institution. This is necessary as it saves the borrower from having to deal with more than one financing agency and also facilitates supervision of credit and recovery of loan instalments. It also eliminates the risk of double financing for the same purpose.

16.7.9 The credit requirement in command areas is large and is much more than what in normal circumstances commercial banks are expected to provide to farmers. A command area of a project may extend over more than one district. Also where the command is large, it may be more than one commercial bank which may have to provide credit facilities for development. These banks, in turn, will have to be given special additional loans to meet the credit requirements for command area development. The Agricultural Refinance Corporation (ARC)[1] has been playing an increasingly important role in refinancing loans given by cooperative land development banks and commercial banks for agricultural development. As the emphasis of the ARC has been on area development, the command area development programmes are expected to figure prominently in the refinancing portfolio of the Corporation. In fact, the success of the development programmes in these areas will largely depend on the extent to which the ARC is able to meet its requirements.

16.7.10 We have drawn attention to the importance of a farmer obtaining his credit requirements both short and long term from a single source. This is particularly important where small and marginal farmers are concerned. This section of the community remained handicapped in securing its requirements and it is for this reason that the setting up of farmers' service societies was proposed. In command areas, by and large, about a quarter of the area pertains to small and marginal farmers. It would be desirable if these people get their total credit requirements, including long term credit for land levelling from FSS.

16.7.11 On preparing the layout plan for a command area, the Land Development Corporation would estimate the cost of land formation for each holding. Adding the share of cost of common facilities such as field channels, field drains and farm roads, the Corporation would prepare a list of credit requirement of each farmer in the command area. On the basis of this requirement, it should approach a commercial bank for accommodation possibly to the extent of 50 per cent of the total requirement to enable it to get on with actual work in the field, while the full credit requirement is being

1 Now Agricultural Refinance and Development Corporation.

examined by the bank. While the amount would be debited to the FSS, it will actually be made over to the Land Development Corporation. This arrangement would avoid delay in starting field work. On completion of the work necessary adjustments in the credit account of each farmer be made. The amount advanced to the Corporation by the commercial banks would thus get finally debited to the farmers' accounts and the Corporation cleared of its loan liability to the banks.

16.7.12 Much of the land development work on the field has to be carried out soon after the rainy season when normally the fields should be under rabi crops. Since the farmer will not be able to grow the crop he will have to be given a sustenance loan on an *ad hoc* basis. This amount would be an item of cost and therefore a part of the long term loan repayable by instalments. Confining the work to a limited period when there is no crop on the field would increase the cost of work due to higher overhead cost and longer idle period of machinery and equipment. It is suggested that an attempt should be made to carry out work in the field for the maximum number of days in a year, even by giving sustenance loans. During such operation periods the idle time of farmers can be used for unskilled work to the extent they may be willing to do the work. This would provide employment and relief to them.

Long Term Credit

16.7.13 Long term loans for command area development have to be advanced against mortgage of land or under Government guarantee where there is no viable asset. It is therefore necessary that the farmer's title to land should be clear. It is not always so. Therefore, well before taking up of command area development in a project area, it becomes important that the land records are brought uptodate. After that has been done and consolidation operations begun, all tenants including share croppers should be identified, their rights recorded and permanent and heritable rights conferred on them. They would then become entitled to long term credit for improvement of land. Even before the consolidation of holdings is undertaken, it would be necessary to enforce the land ceiling law so that the allottees of surplus land become responsible for its development and entitled to credit for the purpose. But where land ceilings cannot be enforced immediately, the loans can be given to the present owner of the land with the proviso that liability for the loan would be fully transferred to the new allottee to the extent it pertains to the allotted land.

16.7.14 Some lands are cultivated on the basis of crop sharing. Tenancy laws mostly stipulate 75 per cent share of the produce to a

sharecropper if he bears all current expenditure. If a loan is advanced for land formation, both the parties should share repayment. But unless the loan stands in the name of the sharecropper also recovery from him would not be in order. This creates a problem. One way of getting round the difficulty would be that the entire loan should be in the name of the landowner but in the arrangement for crop sharing, he should be entitled to recover annually a stipulated amount from the recorded sharecropper towards payment of his share of loan. The arrangement will need to be legalised.

16.7.15 For purposes of entitlement to long term credit, the farmers may be divided into the following categories :

(i) clear title.—willing to take loan to the full extent.
(ii) clear title.—already in debt but willing to take loan to the full extent on an extended period of repayment.
(iii) clear title.—unwilling to take a loan.
(iv) title not clear.—willing to take a loan and having the capacity to repay.
(v) title not clear.—unwilling to take a loan.

Majority of the farmers would fall in category (i). There should be no problem in their securing long term credit from the bank. In the case of category (ii), the bank should determine the paying capacity of the farmer over a longer period than normal and should try to meet the requirement. There may be a small number of farmers in categories (iii) and (v) who may not give their consent for various reasons. Since no part of irrigable land in a command area can be left out of development operation, the Government should provide the necessary funds for completing this work and recover the amount as arrears of land revenue in reasonable instalments. As regards category (iv), such farmers may be allowed credit for the purpose under a Government guarantee.

16.7.16 Before a bank agrees to provide credit for land development in a command area, it has to satisfy itself as to the technical and economic soundness of the proposal and the repayment capacity of the loanee. In turn, the bank has to satisfy the ARC for refinancing the loan advances. The ARC would, therefore, want to carry out a further examination of the technical and economic feasibility of the proposal. It would save time and effort if a land development proposal which a Land Development Corporation sponsors is technically and economically examined to the extent really necessary only by the ARC. The concerned bank can then advance the credit on ARC's certification. After all it is the ARC which has ultimately to provide finance to the bank for this purpose. It would be desirable to appoint a representative of the ARC on the Board of Directors of the Land Development Corporation in the State. This would

build up a better rapport between the ARC and the Land Development Corporation and would facilitate processing of schemes for loans.

16.7.17 In the Fourth Plan, an outlay of Rs. 38 crores was provided for command area development. This amount was intended to be utilised on construction of village roads, development of markets and arranging demonstration on 14 selected major and medium irrigation projects. The actual expenditure was substantially less. In the Draft Fifth Plan, a provision of Rs. 216 crores has been proposed for command area development to be shared between the Centre and the States. This outlay has been provided to meet the cost of establishing Command Area Development Authorities and the constitution of a Water Utilization and Command Area Development Department at State level where the volume of work justifies the creation of a wholetime department. The outlay would also meet the cost of soil surveys, preparation of topographic and contour maps and supervision charges. The equity capital support to Land Development Corporations, farmers' service societies, etc. is also required to be met from this outlay. While this should meet the financial requirements for organisational purposes, it does not cater for the actual land development work in the command areas. That has to be met from institutional sources. Currently not much is being spent on actual land development, the pace being of the order of Rs. one crore per annum. By 1980, the pace of development should reach one million hectare per annum requiring term credit of the order of Rs. 120 to 150 crores per annum from institutional sources. The requirement of short and medium term credit to the farmers for making full use of the irrigation facilities would be in addition. About a quarter of the amount would pertain to small and marginal farmers. They would be entitled to the prescribed subsidy. That may amount to Rs. 8 to 10 crores per annum. This will need to be provided from plan resources. On the basis of constant prices, the requirement of long term credit would be Rs. 170 to 210 crores per annum by 1985. The subsidy element will also increase in proportion.

16.7.18 We wish to particularly emphasise that the full requirement of finance for command area development from institutional sources along with the contribution from governmental sources to the extent it is required to be provided, must be made available to maintain the stipulated pace of development. Any shortfall in this respect would result in corresponding non-utilisation of irrigation potential and to that extent the investment in creating the potential would be idle.

16.7.19 Simultaneously with the taking up of an irrigation project

it will be necessary for the commercial banks in the area to strengthen themselves to cope with the large credit requirements for command area development. In a command area there may be more than one such bank that may be concerned. Thus the strengthening of these banks, possibly by opening more branches, and having larger capital at their disposal will need to be coordinated with the construction of an irrigation project. It is also necessary that the FSS should be established in these districts well in advance so that they are well organised by the time demand on them arises in respect of command area development. All farmers in the command area should be persuaded to join FSS. The recalcitrants should be eligible for loans from other sources but on stiffer terms than those offered by FSS.

16.7.20 As stated in the earlier part of this chapter, a number of command area development authorities have already been established and development work has been taken up in the field under their aegis. For the future we have suggested that the land development work should be entrusted to Land Development Corporations. The financial policies and arrangements which we have discussed in the present section would be equally applicable with some modifications to the existing command area authority pattern of organisation.

8 OTHER MEASURES

16.8.1 Although broad cropping patterns are determined for formulating an irrigation project, it is necessary that adaptive research should be carried out to determine more precisely the cropping patterns which would be suitable in the various parts of the command area. Also the varieties of an individual crop which would be most suitable from consideration of sowing and harvesting time, yield and disease resistance have to be found out. For all this, experimental farms have to be established in the area well before irrigation supplies become available in the command area.

16.8.2 The results obtained from experimental farms have to be demonstrated to farmers so that they may feel convinced and adopt the recommended cropping patterns and varieties. A fairly large number of demonstration farms need to be established. These can be organised as irrigation water becomes available.

16.8.3 Where farmers are not familiar with irrigated farming, they have to be given some training in water management, appropriate tillage practices, raising of irrigated crops and the use of fertilisers and pesticides. This training can begin with the more progressive

farmers. They would, then, disseminate their knowledge to other farmers by actually practising the new techniques of irrigated agriculture. The training course can cover a wide canvas and may include training of women folk in the more efficient way of carrying out work which they have to do in farming.

16.8.4 On an irrigation system, best crop production can only be obtained by an efficient and judicious use of irrigation supplies. This does not always happen. For instance, on a number of irrigation projects, farmers, not fully appreciating the value of water, allow it to run to waste during night. Where there are large blocks of rice fields and irrigation is done from field to field, an outlet left open at night does not necessarily waste water. But in light irrigated crops if there is accumulation of water in a field from an outlet left open at night, there can be serious damage, apart from wastage of water provided at considerable project cost. It has to be appreciated that no canal system can be so regulated that it would supply water only during the day and not at night. Therefore, one way of making sure that farmers would utilise irrigation supplies during night also would be to introduce the system of 'Warabandi' as widely practised in the northern States of Punjab, Haryana, Uttar Pradesh and Rajasthan. In this system, rosters allocating hours and days during which different farmers under the outlet are permitted to draw water are fixed. If a farmer does not utilise the irrigation supplies during his turn, his turn in that particular roster lapses. Generally in a 'Warabandi' two rosters A and B are prepared with a time shift of 12 hours. The rosters are operated alternately so that a farmer who gets his turn at night in roster 'A' gets his turn during the day in roster 'B'. 'Warabandi' not only ensures that farmers who are desirous of making use of irrigation supplies do so even during the night, but also protects the interest of the weaker farmers who without a 'Warabandi' may be deprived of their due share of supplies during a period of keen demand. If a farmer violates 'Warabandi', under the Canal and Drainage Act of Northern India, he is liable to a fine or imprisonment or both.

9 SUMMARY OF RECOMMENDATIONS

16.9.1 The recommendations given below are not comprehensive. Only the more important ones are stated here for special notice.

1. All the steps necessary for development of land in a command area have to be taken together in an integrated manner. These

comprise :

(i) layout of plots and of common facilities like water courses, field channels, drains and farm roads;
(ii) consolidation of farmer's scattered plots into one or two operational holdings;
(iii) construction of watercourses and field channels;
(iv) construction of field drains where necessary and linking them with connecting drains;
(v) provision of farm roads; and
(vi) land formation to suitable slopes.

(Paragraphs 16.3.2 and 16.3.21)

2. For the layout of fields and other facilities the contour method of layout is recommended.

(Paragraph 16.3.22)

3. The maps for land development in the command area should be on a scale of 1:2,500 or 1:4,000 with 10 cm contour intervals.

(Paragraph 16.3.3)

4. Land Preparation for irrigation on steeper slopes becomes expensive and in areas with natural slopes exceeding 10 per cent it may cost so much as to make introduction of irrigation uneconomical.

(Paragraph 16.3.12)

5. It is desirable that small holdings should be grouped in a contiguous area near the periphery of the village. Within the command of an outlet, the smaller holdings should be located at the beginning of the watercourse and the larger ones farther away. This will facilitate equitable distribution of water to the small holdings.

(Paragraph 16.3.19)

6. Once approval of government is accorded to the preparation of a project report, the Irrigation Department should immediately notify other concerned departments of this approval, and giving an outline of the project, advise them to take up investigation of the items which pertain to them. These concerned departments should prepare their own estimates for any field investigation which they may need to carry out and obtain the necessary sanction and funds through their own departmental channels.

(Paragraph 16.4.2)

7. An irrigation project report should be prepared in three parts besides the general report as under :—

Part I—all engineering works from source of supply up to outlets, including drains.

Part II—all engineering works in the command area comprising land levelling and shaping, construction of watercourses, lined or unlined, field channels, field drains

and farm roads.

Part III—all other items pertaining to agriculture, animal husbandry, forestry, fishery, communications and co-operation.

(Paragraph 16.4.1)

8. The general report and Part I and II of the project report should be prepared by the Irrigation Department. As the work involved in Part II of the report is not being handled by the Irrigation Department at present, that department should organise a special set up for the purpose for which agricultural engineers should also be inducted into the department. The personnel should be given the necessary training. The Part III of the report should be prepared by the concerned departments and sent to the Irrigation Department for compilation. The Irrigation Department should then submit the complete report comprising all the parts for sanction to the appropriate authority.

(Paragraph 16.4.3)

9. In Part III of the report, the Agriculture Department should deal with tillage practices, cropping pattern, production of seeds and their distribution, requirement and distribution of fertilisers and manures, soil testing, plant diseases and distribution of pesticides, role of agro-industries, extension services, horticulture, transportation, storage and marketing and credit facilities.

(Paragraph 16.4.11)

10. The Animal Husbandry Department should deal with the requirement of livestock, fodder and feed, the dairy development arrangements for processing and marketing and extension services.

(Paragraph 16.4.12)

11. The Forest Department should indicate the proposals for farm forestry, raising of grasses, arrangement for nurseries and extention organisation. The scheme for irrigated forest plantation may also be included.

(Paragraph 16.4.13)

12. The Fisheries Department should be consulted in respect of the extent to which reservoir area should be cleared of trees and scrub, the structures to be provided in the interest of fishery and the minimum flows that may be required from the reservoir for riverine fishery. These matters should be included in Part I of the report. In Part III they should deal with the arrangements for fishery in the reservoir, setting up of seed fish, farms, the scope and proposals for pond and tank fisheries in the command areas, leasing policy, credit facilities, and marketing and processing arrangements.

(Paragraph 16.4.14)

13. Land formation work should be taken in hand concurrently

with the construction of irrigation channels.

(Paragraph 16.5.2)

14. At present, command area awaiting land formation work is of the order of 10 Mha, including that where irrigation supplies would become available in the next two to three years. Land formation work would need to be completed in about 30 Mha by the year 2000.

(Paragraph 16.5.3)

15. The problems pertaining to organisation and finance in command area development should be given immediate and serious attention.

(Paragraph 16.5.4)

16. Proper land formation is equally important in the commands of minor irrigation projects. By the turn of the century there would be about 9 Mha that would have required action. In the case of groundwater, the sinking of tubewell and the land development in its command should be a single composite work to be carried out simultaneously.

(Paragraph 16.5.5)

17. It would be desirable that the work of land development should be placed under the purview of the same department as is responsible for the construction of irrigation works, namely, the Irrigation Department.

(Paragraph 16.6.19)

18. The land development works should be entrusted to Land Development Corporation. The Corporation should be invested with the necessary authority to enable it to adequately discharge its functions. To begin with it should borrow technical and skilled personnel particularly for its top echelon from the Irrigation, Agriculture and other departments making also direct recruitment. Gradually it should have mostly its own staff. Agricultural and other engineers which it may recruit should be put through a course of training to specialise for the work. At the secretariat level the corporation should be the responsibility of the Irrigation Department.

(Paragraph 16.6.20)

19. In some States the agro-industries corporations have taken up the land levelling work. Since the work has to be done along with the construction of watercourses, field drains and farm roads as a single operation, the agro-industries corporation is not the best agency for this work.

(Paragraph 16.6.23)

20. There should be a legal provision that once it is declared that in a command area land formation operations are to be taken up consolidation of holdings would be obligatory. It would be desirable

to deploy special revenue staff well in advance of the land development activities to bring land records up-to-date before actual start of work.

(Paragraphs 16.6.24 and 16.7.13)

21. During the period the Land Development Corporation is engaged in land formation in a command area, there should be a Project Development Officer in overall charge so that the requirements of farmers during the transition period receive concentrated attention and the various activities in the command area get properly coordinated.

(Paragraph 16.6.25)

22. Considering the magnitude of the land formation work to be undertaken the most sophisticated techniques of mapping will need to be adopted from consideration of speed of work, accuracy and cost. It would be advisable to have a separate Land Survey and Mapping Corporation or a separate Command Area Mapping Wing under the same Ministry as administers the Survey of India, for the purpose. This organisation would also arrange for ground control work and detailed levelling necessary for preparing accurate contour maps from photographs. This Corporation or the Wing can initially draw some of the required personnel from the Survey of India and Indian Photo-Interpretation Institute, Dehra Dun.

(Paragraphs 16.6.26 and 16.6.27)

23. Aerial photographs and most of the maps are at present treated as restricted material for security reasons and as such are not available freely even to government departments for planning developmental work. If the developmental work is not to be unduly hampered, then it is necessary that these restrictions should be relaxed to the maximum extent feasible.

(Paragraph 16.6.29)

24. In order that the preparation of the irrigation project report is not delayed, it would be necessary to have a planning cell at State headquarters in each of the concerned departments dealing with other fields of development such as agriculture, animal husbandry, fisheries, forests, cooperative etc. which would devote sustained attention to formulation of proposals in respect of command areas.

(Paragraph 16.6.30)

25. The Land Development Corporation would carry out land formation work on behalf and at the cost of the farmers, allowing for any subsidy which the Centre or the State may give for the purpose. The Corporation would require some funds of its own for equipping itself with the necessary equipment and machinery and for meeting the organisational expenses. The funds required for actual work have to come from institutional sources as long term loan to

individual farmer passed on to the Corporation for the purpose.

(Paragraph 16.7.7)

26. The farmer should be enabled to obtain all his loan requirements, short, medium and long terms, from one and the same institution. This is particularly important where small and marginal farmers are concerned. As such the setting up of farmers' service societies should be given priority in the command areas.

(Paragraphs 16.7.8 and 16.7.10)

27. The Land Development Corporation should be given an accommodation to the extent of 50 per cent of the total requirement to enable it to get on with the actual work in the field after the plans for a particular area have been drawn up, while the full credit requirement is being examined by the bank. On completion of the work necessary adjustments in the credit account of each farmer should be made. The amount advanced to the Corporation would thus get finally debited to the farmers' account and the Corporation cleared of its loan liability to the bank.

(Paragraph 16.7.11)

28. Every attempt should be made to carry out the work in the field for the maximum number of days in a year even by giving sustenance loans to farmers on their having to miss a crop in the process. During land formation operation the idle time of farmers can be used for non-skilled work to the extent they be willing to do the work. This would provide employment and relief to them.

(Paragraph 16.7.12)

29. Even before the consolidation of holdings is undertaken, it would be necessary to enforce the land ceiling law so that the allottees of surplus land become entitled to credit. But where land ceiling cannot be enforced immediately the loan can be given to the present owner with the proviso that liability for the loan would be transferred to the new allottee to the extent it pertains to the allotted land.

(Paragraph 16.7.13)

30. In the case of sharecropper the entire loan should be in the name of the landowner. But in the arrangement for crop sharing, he should be entitled to recover annually a stipulated amount from the recorded sharecropper towards payment of his share of loan. This arrangement should be legalised.

(Paragraph 16.7.14)

31. Since no part of the irrigable land in the command area can be left out of the development operation, Government should provide the necessary funds for completing this work and recover the amount as arrears of land revenue in reasonable instalments in the case of those farmers who are unwilling to take a loan. In the case of farmers whose title is not clear but who are willing to take a loan and

have the capacity to repay, the credit should be allowed by the financial institution under a Government guarantee.

(Paragraph 16.7.15)

32. Since it is the ARC which has ultimately to provide finance to the bank or the cooperative societies for land development work, it would be desirable to appoint a representative of the ARC on the Board of Directors of the State Land Development Corporation. The land development proposal which the Corporation may sponsor should be technically and economically examined, to the extent really necessary, only by the ARC. The bank can then advance the credit on ARC's certification.

(Paragraph 16.7.16)

33. By 1980 the pace of land development should reach one million hectares per annum requiring term credit of the order of Rs. 120—150 crores per annum from institutional sources. This would further rise to Rs. 170—210 crores per annum by 1985.

(Paragraphs 16.6.12 and 16.7.17)

34. The full requirements of finance for command area development from institutional sources along with the contribution from Governmental sources to the extent it is required to be provided, must be made available to maintain the stipulated pace of development.

(Paragraph 16.8.18)

35. Experimental farms should be established in the command area well before irrigation supplies become available. A fairly large number of demonstration farms would need to be established as irrigation water becomes available. The farmers should be given training in water management, appropriate tillage practices, raising of irrigated crops and the use of fertilisers and pesticides. Likewise, training of womenfolk in the more efficient way of carrying out farming duties should be arranged.

(Paragraphs 16.8.1, 16.8.2 and 16.8.3)

36. In any new irrigation system night irrigation should also be enforced through the system of 'Warabandi'. This system of 'Warabandi' would also protect the interests of the weaker farmers who may be otherwise deprived of their due shares of supply during a period of keen demand.

(Paragraph 16.8.4)

APPENDIX 16.1

(Paragraph 16.3.16)

Submergence Damage of Rice According to Growth Stage in Japan[1]

(percentage reduction in yield[2])

Crop-growth stage	Days of submersion							
	clear water				muddy water			
	1-2	3-4	5—7	+7	1-2	3-4	5—7	+7
20 days after transplanting . .	10	20	30	35				
young panicle formation partly inundated[3]	10	30	65	90–100	20	50	85	90–100
young panicle formation completely inundated . . .	25	45	20	80–100	70	80	85	90–100
heading stage	15	25	30	70	30	80	90	90–100
ripening stage	0	15	20	20	5	20	30	30

1 Sources: H. Fukuda and H. Tsutsui, Irrigation in Japan, Food and Agriculture Organisation, Rome.
2 Damage figures are reduced by 50 per cent for half-day submersion.
3 "partly" means leaves (9 to 15 centimetres long) remain above water surface.

APPENDIX 16.2

(Paragraph 16.3.16)

Submergence Damage of Rice According to Growth Stage in Korea[1]

(percentage reduction in yield)

Crop-growth stage	dates	Days of submersion							
		clear water				muddy water			
		1	3	5	7	1	3	5	7
tillering period	mid-July	25	55	100	100	30	100	100	100
panicle formation	early Aug.	15	45	90	95	20	50	90	100
head sprouting	late Aug.	25	95	100	100	45	100	100	100
after-flowering	early Sept.	15	50	50	50	45	85	85	85
milky stage	mid-Sept.	5	5	10	10	15	35	40	65
ripening		5	20	20	30	10	20	30	30

1 Source: Report on the Mokpo's Yongsan Scheme, Food and Agriculture Organisation, Rome, 1965.

(Paragraph 16.3.34)

APPENDIX 16.3

Cultivable land Before and After Land Preparation, Pochampad Project—Andhra Pradesh

(area in hectares)

Items	Porumella village		Koratia village		Porandla village		Morapally village	
brief particulars :								
1. channel . . .	6L of D53		SDL4—D 40		3R—D53		IL—D53	
2. outlet number . . .	DP 4		FCP—3		DP 25		DP 5	
3. gross command area of outlets	25.33		24.80		32.51		17.80	
4. cultivable command area of outlets	23.72		22.62		29.99		16.31	
5. average size of plots or land holdings	1.15		0.59		0.81		0.68	
area occupied by : . . .	Before	After	Before	After	Before	After	Before	After
1. field boundaries . . .	0.26	1.09	0.13	1.13	0.26	1.66	0.21	0.75
2. watercourses and field channels	Nil	0.30	Nil	0.54	Nil	0.40	Nil	0.36
3. (a) connecting drains . .	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
(b) field drains . . .	Nil	0.22	Nil	0.51	Nil	0.46	Nil	0.38
4. farm roads	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
area available for cultivation .	25.33	23.72	24.67	22.62	32.25	29.99	17.59	16.34

APPENDIX 16.3 (*Contd.*)

Cultivable Land Before and After Land Preparation, Chambal Project—Madhya Pradesh

(area in hectares)

Items	Kareri Shatari village		Hadwasi village		Hingona Khurd village		Gurikha village		Sujarma II village		Surehra village	
brief particulars :												
1 channel.	1O-L distributory		Morana branch canal		26 R distributory of ABC		A 10-L distributory of main canal		3R of SL distributory of LMC		Lower main canal	
2. outlet No.	IP		D. O. No. 6		Not given		I		district outlet		D.O. No. 1	
3. gross command area of outlets	42.67		42.15		34.39		51.94		46.54		44.21	
4. cultivable command area of outlets	40.08		39.10		32.47		43.42		38.07		38.91	
5. average size of plots or land holdings	2.12		0.72		1.20		1.08		0.88		0.87	
area occupied by :	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1. field boundaries	0.60	1.45	0.40	0.44	1.21	0.44	2.83	7.58	2.15	5.66	2.10	1.48
2. watercourses and field channels	Nil	0.47	0.40	0.82	0.28	0.48	0.20	0.60	0.43	0.36	0.58	0.61
3. (a) connecting drains .	Nil	Nil	..	0.36	..	..	..	0.28	..	0.90	..	..
(b) field drains	10.00	0.36	18.50	1.43	15.00	0.40	15.50	..	18.50	1.55	26.50	0.28
	(natural ravines & gullies)		(waterlogged)		(waterlogged)		(waterlogged)		(waterlogged)		(waterlogged)	
4. farm roads	..	..	..	..	1.41	1.21	0.12	0.06	0.89	..	0.70	2.96
5. area available for cultivation .	20.00	22.67	22.49	39.10	16.50	32.47	32.29	43.42	24.60	38.07	14.47	38.91

APPENDIX 16.3 (*Contd.*)

Cultivable Land Before and After Land Preparation, Tawa Project—Madhya Pradesh

(area in hectares)

Items	Tarondadhana village		Sonasaori village		Biora village	
brief particulars :						
1. channel	Tarondadhana Minor I		Sonasaori II-5		Biora Minor	
2. outlet No.	9R		IR & 2R		7R	
3. gross command area of outlets	42.50		79.45		20.44	
4. cultivable command area of outlets	41.47		73.95		19.26	
5. average size of plots or land holdings	1.50 to 2.00		1.60		1.00	
area occupied by :	Before	After	Before	After	Before	After
1. field boundaries	0.64	1.05	1.62	0.97	..	..
2. watercourses and field channels	..	0.54	..	..	..	0.34
3. (a) connecting drains	..	0.38	1.20	0.82	..	0.28
(b) field drains	..	0.04	..	1.00	..	..
4. farm roads	..	0.53	2.25	3.63	..	0.56
area available for cultivation	43.60	41.70	74.38	73.95	20.44	19.26

APPENDIX 16.3 (*Contd.*)

Cultivable Land Before and After Land Preparation, Gandak Project—Bihar

(area in hectares)

Items	Parsauni-Bherihari village		Balgangwa-Bherihari village		Balgangwa-Bherihari village		Balgangwa-Bherihari village		Dhum Nagar village	
brief particulars :										
1. channel	Laxmipur minor Ex 19.06 RD of TMC		Laxmipur minor Ex 19.06 RD of TMC		Laxmipur minor Ex 19.06 RD of TMC		Laxmipur minor Ex 19.06 Rd of TMC		Sophwa minor	
2. outlet No.	OL I		direct outlet from 9.4 RD		OR 2		OR		'2L'	
3. gross command area of outlets	213.00		169.00		26.05		35.50		82.56	
4. cultivable command area of outlets	149.00		118.00		18.5		24.80		75.47	
5. average size of plots or land holdings	1.84		1.20		0.44		0.60		0.03 to 0.67	
area occupied by :	Before	After	Before	After	Before	After	Before	After	Before	After
1. field boundaries	0.53	0.53	0.44	0.44	0.04	0.04	0.06	0.05	4.80	1.20
2. watercourses and field channels	0.95	4.08	1.15	3.44	Nil	0.65	Nil	0.76	..	1.60
3. (a) connecting drains	Nil	0.30	Nil	0.20	Nil	0.30	Nil	0.35	..	0.80
(b) field drains	Nil	1.28	Nil	0.92	..	..	..	0.09	..	..
4. farm roads	1.73	1.73	0.74	0.74	0.04	0.04	0.11	0.11	..	0.40
area available for cultivation	145.79	141.08	115.68	112.27	18.48	17.48	24.64	23.44	73.20	75.60

APPENDIX 16.3 (*Contd.*)

Cultivable Land Before and After Land Preparation, Kosi Project-Bihar

(area in hectares)

Items	Harda village		Harda Village	
brief particulars :				
1. channel	Pirganj minor		Pirganj minor	
2. outlet No.	No. 1		No. 3	
3. gross command area of outlets	22.42		18.21	
4. cultivable command area of outlets	21.08		17.20	
5. average size of plots or land holdings	before development 0.08 after development 0.14		before development 0.11 after development 0.26	
area occupied by :	Before	After	Before	After
1. field boundaries	0.51	0.32	0.40	0.19
2. watercourses and field channels	0.32	0.25	0.23	0.33
3. (a) connecting drains	..	0.05	..	0.06
(b) field drains	..	0.14	..	0.15
4. farm roads	0.57	0.57	..	0.30
area available for cultivation	21.02	21.08	17.87	17.20

APPENDIX 16.3 (*Concld.*)

Cultivable Land Before and After Land Preparation, Jayakwadi Project—Maharashtra

(area in hectares)

Items	Gondi		Gondi		Antarwali(s)		Patharwala wadigodri		Patharwala (kd.)		Shahagad Walkeshwar	
brief particulars :												
1. channel	19/4		19/4		17/-		17/-		17/-		15/-	
2. outlet No.	OR-1		OL-1		OR-5		OR-6		OR-10		OL-16	
3. gross command area of outlets	64.30		81.85		57.80		78.70		54.89		50.23	
4. cultivable command area of outlets	24.00		47.32		31.69		46.10		15.87		29.52	
5. average size of plots or land holdings	0.75/3.50		0.71/5.30		0.38/2.50		0.40/3.25		0.45/1.00		0.59/4.00	
area occupied by :	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1. field boundaries	1.46	0.21	3.18	1.56	7.75	1.80	2.25	1.84	0.51	0.64	2.80	0.77
2. watercourses and field channels	..	0.31	..	0.52	..	0.83	..	0.96	..	0.38	..	0.63
3. (a) connecting drains	..	..	..	..	..	..	..	..	..	..	..	..
(b) field drains	..	0.22	..	0.22	..	0.25	..	0.41	..	0.20	..	0.31
5. farm roads	..	0.70	..	0.82	..	0.95	..	1.96	..	0.47	..	1.07
area available for cultivation	22.54	22.56	44.14	44.20	23.94	27.86	43.85	40.93	15.36	14.18	26.72	26.74

APPENDIX 16.3 (*Contd.*)

Cultivable Land Before and After Land Preparation, Kosi Project-Bihar

(area in hectares)

Items	Harda village		Harda Village	
brief particulars :				
1. channel	Pirganj minor		Pirganj minor	
2. outlet No.	No. 1		No. 3	
3. gross command area of outlets	22.42		18.21	
4. cultivable command area of outlets	21.08		17.20	
5. average size of plots or land holdings	before development 0.08 after development 0.14		before development 0.11 after development 0.26	
area occupied by :	Before	After	Before	After
1. field boundaries	0.51	0.32	0.40	0.19
2. watercourses and field channels	0.32	0.25	0.23	0.33
3. (a) connecting drains	..	0.05	..	0.06
(b) field drains	..	0.14	..	0.15
4. farm roads	0.57	0.57	..	0.30
area available for cultivation	21.02	21.08	17.87	17.20

APPENDIX 16.3 (*Concld.*)

Cultivable Land Before and After Land Preparation, Jayakwadi Project—Maharashtra

(area in hectares)

Items	Gondi		Gondi		Antarwali(s)		Patharwala wadigodri		Patharwala (kd.)		Shahagad Walkeshwar	
brief particulars :												
1. channel	19/4		19/4		17/-		17/-		17/-		15/-	
2. outlet No.	OR-1		OL-1		OR-5		OR-6		OR-10		OL-16	
3. gross command area of outlets	64.30		81.85		57.80		78.70		54.89		50.23	
4. cultivable command area of outlets	24.00		47.32		31.69		46.10		15.87		29.52	
5. average size of plots or land holdings	0.75/3.50		0.71/5.30		0.38/2.50		0.40/3.25		0.45/1.00		0.59/4.00	
area occupied by :	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1. field boundaries	1.46	0.21	3.18	1.56	7.75	1.80	2.25	1.84	0.51	0.64	2.80	0.77
2. watercourses and field channels	..	0.31	..	0.52	..	0.83	..	0.96	..	0.38	..	0.63
3. (a) connecting drains	..	..	..	..	..	..	..	..	..	..	..	..
(b) field drains	..	0.22	..	0.22	..	0.25	..	0.41	..	0.20	..	0.31
5. farm roads	..	0.70	..	0.82	..	0.95	..	1.96	..	0.47	..	1.07
area available for cultivation	22.54	22.56	44.14	44.20	23.94	27.86	43.85	40.93	15.36	14.18	26.72	26.74

APPENDIX 16.4

(Paragraphs 16.6.6 and 16.6.14)

Command Area Development Authorities—Constitution of

Resolution No. IPM 1074-I(5)-CADA
Irrigation and Power Department
Resolution No. IPM 1074-I(5)-CADA
Sachivalaya, Bombay-400 032, dated 15th April, 1974

READ :—

(i) Irrigation Commission's Report, Chapter VII on Ayacut Development.

(ii) Interim Report of the National Commission on Agriculture on modernising irrigation systems and integrated development of command areas.

(iii) Letters from Shri F. A. Ahmed, Minister of Agriculture, Government of India, dated the 19th May, 1973 and 16th August, 1973.

(iv) Chapter XIII on Command Area Development from the Planning Commission's Fifth Five Year Plan—Part II.

(v) Letter D.O. No. F. 11-9-1973 from the General Administration Department to the Secretary to the Government of India, Ministry of Agriculture, dated 1st September, 1973.

Substantial investment has been made on irrigation projects in the post-1960 period. The returns by way of increased agricultural production from the completed irrigation projects have, however, not been satisfactory due to under-utilisation of irrigation potential. This inadequate utilisation of available irrigation potential is particularly distressing in the context of low per acre availability of water resources in Maharashtra, comparatively higher costs of construction and maintenance of irrigation projects and the continuing shortages of foodgrains in the State. Several causes of inadequate utilisation have been by now enumerated by various studies and enquiries made at the National and State level. It is now imperative that concentrated attention be paid to irrigated areas to set right this state of affairs and to secure efficient utilisation of available irrigation potential and optimum agricultural production from irrigated lands.

RESOLUTION :—With a view to expeditious development of the command areas the Government of Maharashtra has, in consultation with Government of India, decided to set up Command Area Development Authorities for the following projects or groups of projects :—

(1) Purna and Jayakwadi Projects;

(2) Ghod and Bhima Projects including Pawna command area ;

(3) Girna and Upper Tapi (Hatnur) Projects ;

(4) Bagh, Itiadoh and Pench Projects; and

(5) Krishna Project.

2 The functions of the Command Area Development Authority will be as follows :—

(1) Maintenance and efficient operation and modernisation, where necessary, of the irrigation system in the command area up to the outlets with one cusec capacity ;

(2) Development and maintenance of the main and subsidiary drainage system in the Command Area ;

(3) Conducting Soil Surveys in the Command Area, with a view to determining and modifying from time to time most suitable cropping patterns ;
(4) Ensuring efficient maintenance of the Field Channels and the Field Drains within the Command Area by the concerned farmers and by the Authority at their cost, if necessary ;
(5) Land levelling and Land shaping on its own, and/or through other agencies, at the cost of the beneficiary farmers ;
(6) Prescribing and enforcing an appropriate system of distribution and regulation of water supply throughout the Command Area ;
(7) Development of Groundwater Resources and ensuring its conjunctive use along with surface irrigation ;
(8) Selection, introduction and enforcing of suitable cropping patterns ;
(9) Localization and delocalization of lands for various crops ;
(10) Ensuring supplies of all inputs and services including credit ;
(11) Development of marketing, processing and storage facilities and an adequate communications system ;
(12) Development of subsidiary activities in the fields of Animal Husbandry, Dairy, Poultry, Farm-Forestry, Fishery, Horticulture etc. ;
(13) Soil Conservation and afforestation, where necessary ;
(14) Consolidation of land holdings and re-drawing of field boundaries on an outlet command basis, where necessary ;
(15) Organising Agricultural Co-operatives ;
(16) Town Planning and Development of Growth Centres within the Command Area ;
(17) Co-ordinating the activities of the Institutional Agencies, in the Command Area such as the Land Development Banks, Co-operative Credit Institutions, Branches of the Nationalized Banks, etc. ;
(18) Co-ordinating the research activities, including those undertaken by the Agriculture University in the Command Area ;
(19) Co-ordination with the Revenue and other Departmental authorities functioning within the Command Area ;
(20) Ordering or undertaking studies, enquiries or adoptive research for effective application of scientific principles of soil and water management and to evolve and to implement packages of practices for different crops in the command areas ;
(21) Development of farmer support services and organisation of programmes or campaigns to educate farmers in the command areas for efficient utilisation of irrigation potential or maximising agricultural production ;
(22) Implementation generally of all policies of the Government of India and the State Government in respect of the intensive development of the Command area.

3 The jurisdiction of the 5 Command Area Development Authorities will be as shown in Annexure I.

4 Each Command Area Development Authority will have a Board consisting of a President and Members as shown in Annexure II.

5 (i) The Board will approve the annual programme, review its implementation, and effect co-ordination between the different departments and development agencies. Once a programme and a plan of action is approved by the Command Area Development Authority it would be binding on all the departments concerned, and it would be the duty of all the departments concerned to implement

them faithfully ;

(ii) It will have full powers to take all decisions pertaining to the development of the command area(s), subject to the general policy directions which may be given by Government and subject to the final provisions made in the Plan/Budget.

6 The Board may frame detailed rules regarding the number of meetings to be held, the manner of recording minutes of its meetings etc. and other matters connected with its working.

Executive Agencies of Command Area Development Authorities

(a) Executive Committee

7 Each Command Area Development Authority will have an Executive Committee consisting of a Chairman and the following members:

(1) Chairman;

Members

(2) Commissioner of the Division;
(3) Administrator of the Command Area Development Authority;
(4) Superintending Engineer/s of the project;
(5) Superintending Agricultural Officer of the Project;
(6) Joint Registrar of the Co-operative Societies of the Project;
} or seniormost officer of each of these three disciplines working on project;
(7) Three non-officials nominated;
(8) By the Board on the Executive Committee; and
(9) Secretary—Deputy Administrator of the Project.

8 The Executive Committee will attend to and take decisions on routine day-to-day matters as also such other matters as may be delegated to it by the Command Area Development Authority Board.

9 The Executive Committee will meet at least once a month at a place within the Project Area as may be decided by the Chairman.

(b) Chairman

10 The Chairman will be the Chief Executive of the Command Area Development Authority. He will exercise all powers of the Head of Department in respect of functions listed in Annexure III. Statutory powers under the Acts administered by the respective Departments are excluded unless any of those are also specially delegated to the Chairman.

11 Until an independent Chairman is appointed for any Command Area Development Authority, the Divisional Commissioner of the Revenue Division in which the command area is situated will be ex-officio Chairman of the Executive Committee.

(c) Administrator

12 An Administrator shall be appointed for each Command Area Development Authority as a full time officer who shall, subject to the control of the Board and the Chairman of the Executive Committee be responsible for implementing the policies and programmes formulated by the Board or the Executive Committee and for implementing the directions received from time to time from Government in respect of the functions of Command Area Development Autho-

rity listed in para 2 above. The Administrator shall be the Vice-Chairman of the Executive Committee. All other officers of Command Area Development Authority will work under his directions. In respect of Command Area Development Authority area and functions, the Administrator will have all administrative and financial powers which are exercised by the Collectors of the districts and regional officers of Irrigation and Power, Agriculture and Co-operation Departments.

13 Five posts of Administrators, one for each Command Area Development Authority, in the senior time scale of I.A.S. (Rs. 900-50-1000-60-1600-50-1800) or in the scale of Superintending Engineer of Irrigation and Power Department (Rs. 1300-60-1600) or Joint Director of Agriculture (Rs. 1300-60-1600) are created with immediate effect. The operative scale will be of the cadre or service to which the officer belongs. Orders for creating posts of supporting staff to the Administrators will be issued separately.

14 Development Boards previously created under Government Resolutions (listed below) for Jayakwadi, Bhima, Girna-Upper Tapi, Bagh-Itiadoh and Pench, and Krishna Projects and the Co-ordination Committee created for Purna Project are hereby superseded.

(1) Government Resolution, Irrigation and Power Department No. PIM 3171-IP(2), dated the 20th July 1971,

(2) Government Resolution, Irrigation and Power Department, No. JAY 2372/31293-IP(2), dated the 23rd May 1972.

(3) Government Resolution, Irrigation and Power Department, No. KRN 2372/31728-IP(2), dated the 5th June 1972,

(4) Government Resolution, Irrigation and Power Department, No. BHM 2070-IP(4), dated the 27th June 1972,

(5) Government Resolution, Irrigation and Power Department, No. MIP 2273/23518-IP(4), dated the 11th April 1973,

(6) Government Resolution, Irrigation and Power Department, No. MIP 2073/109240-IP(4), dated the 14th November 1973, and

(7) Government Resolution, Irrigation and Power Department, No. PRN 1071/34877-I(S), dated the 9th August 1972.

The existing posts of Project Development Officers will stand abolished from 1st May 1974.

15 The non-official members of the Board will be eligible to draw travelling allowance and daily allowance admissible under Scale-II of Rule 1(1)(b) of Section-I, Appendix XLII-A of the Bombay Civil Services Rules, Volume-II for attending the meetings of the Board. The Members of Parliament, Legislative Assembly and Legislative Council should be entitled to draw travelling allowance and daily allowance as per the orders issued under Government Resolution, Finance Department, No. TRA. 1470/131/XVIII, dated the 27th January, 1971. The expenditure on that account and contingent expenditure should be met from the sanctioned grant for the Command Area Development Authority who will also be the Secretary of the Board will be the controlling authority in respect of travelling allowance bills of non-official members of the Board.

16 This Government Resolution issues with the concurrence of the Finance Department *vide* its un-official reference No. 639/S-3, dated the 15th April 1974.

By order and in the name of the Governor of Maharashtra.

K. V. DESAI,
Command Area Development Commissioner
and Secretary to the Government of Maharashtra.

COMMAND AREA DEVELOPMENT AUTHORITY BOARD

PRESIDENT

Shri S. B. Chavan,

Minister (Agriculture)

MEMBERS

Dr. Rafiq Zakaria, Minister (Public Health, Urban Development).

Shri Kalyanrao P. Patil, Minister of State (Industries).

Shri Sundarrao A. Solankhe, Minister of State (Revenue).

Command Area Development Commissioner and Secretary, Irrigation and Power Department Sachivalaya.

Divisional Commissioner, Aurangabad.

Representative of the Ministry of Agriculture, Government of India.

Collector, Aurangabad.

Collector, Parbhani.

Collector, Nanded.

Chief Executive Officer, Zilla Parishad, Aurangabad.

Chief Executive Officer, Zilla Parishad, Parbhani.

Chief Executive Officer, Zilla Parishad, Nanded.

Superintending Engineer, Aurangabad Irrigation Projects Circle, Aurangabad.

Superintending Engineer, Jayakwadi Canal Circle, Aurangabad.

Superintending Agricultural Officer, Aurangabad.

Jt. Registrar of Co-op. Societies, Aurangabad.

Regional Fisheries Development Officer, Aurangabad.

Regional Jt. Director, Animal Husbandry, Aurangabad.

Joint Director of Industries, Aurangabad.

Shri V.B. Taradekar, Member, Lok Sabha, Nanded.

Shri S.S. Deshmukh, Member, Lok Sabha, Hingoli, District Parbhani.

Shri B.J. Kale, Member, Lok Sabha, Seegaon, District Aurangabad.

Shri Manikrao Palodkar, Member, Lok Sabha, Palod, Taluka Sillod, District Aurangabad.

Shri Ankushrao Raosaheb Tope, M.L.A., At Post Patharwala BK., Taluka Ambad, District Aurangabad.

Shri Haribhau Ramrao Burkule, M.L.A. At Khandvi Post Usmanapur Taluka Partur, District Parbhani.

Shri Raosaheb Bapusaheb Jamkar, M.L.A., Parbhani.

Shri Vithalrao Champatrao Mhaske, M.L.A., At Chinchardi, Post Kalamnuri, District Parbhani.

Shri Sakharam Gopalrao Nakhate, M.L.A., Parbhani.

Shri S. Ekbal Husain, M.L.A., At Post Purna (J), Taluka & District Parbhani.

Shri Trimbak Maroti Sawant, M.L.A., At post Kodri, Taluka, Cangakhed District Parbhani.

Shrimati Ashatai Marotiappa Tale, M.L.A., Hingoli.

Shri Sayyad Farukh Pasha Sayyad Makdum Pasha, M.L.A., Nanded.

Shri Shamrao Sakharam Kadam, M.L.C., Nanded.

Shri Abasaheb Dattarao Deshmukh (Lahankar), M.L.C., Shivajinagar, Nanded.

Shri Annasaheb Ramchandra Gavhane, M.L.C., Parbhani.

Shri Manikarao Shankarrao Mhaske, M.L.C., Parbhani

Shri N.L. Bhale, Associate Dean (Research), Marathwada Krishi Vidyapith, Parbhani

Shri Shyamrao S. Patil, Vice-President, Zilla Parishad, Aurangabad

Shri Shrimantrao Appaji, Chairman, Panchayat Samiti, Paithan

Shri Kishanrao Chaburao, Chairman, Panchayat Samiti, Ambad

Shri Badriprasad Barwale, Jalna.

Shri Sakheram Patil, Rajapimpri, T. & P. Aurangabad (Aurangpura, Aurangabad)

President, Zilla Parishad, Aurangabad

President, Zilla Parishad, Parbhani

President, Zilla Parishad, Nanded.

MEMBER-SECRETARY

Administrator, Purna—Jayakwadi Projects Command Area Development Authority, Aurangabad.

APPENDIX 16.5

(Paragraph 16.6.7)

Command Area Development Authorities for Ukai and Kadana Command Areas—Establishment of—Creation of Posts of Area Development Commissioners for Ukai and Kadana Command Area.......

GOVERNMENT OF GUJARAT
Agriculture, Forests & Cooperation Department,
Resolution No. ADA-1073-(1564)-K,
Sachivalaya, Gandhinagar,

Dated, the 16th May, 1974

READ :—

(i) Irrigation Commission's Report Chapter VII on Ayacut Development.

(ii) Interim Report of the National Commission on Agriculture on modernising irrigation systems and integrated development of command areas.

(iii) Letters from Shri F. A. Ahmed, Minister of Agriculture, Government of India, dated the 19th May, 1973 and 16th August, 1973.

It has generally been the experience in the country that there is substantial under-utilisation of the irrigation potential created by big irrigation projects. This implies that much of the investments made on such irrigation projects remain inpuctuous. It has been found that one of the main reasons for such under-utilisation is that there has been no planned effort to develop the entire Command Area of the irrigation project to a position where the available water from the dam could be put to optimum benefits. Various activities, such as, land levelling, land shaping, constructing field channels, setting up a drainage system, strengthening of cooperatives, survey of soils and topography, and most important of all, training of farmers in proper water utilisation measures, have to be carried out for this purpose. The Irrigation Commission as well as the National Commission on Agriculture have emphasised the need for special organisational arrangements in the Command Areas of big irrigation projects to draw up and implement programmes for integrated Command Area Development.

RESOLUTION :—

Government have, therefore, decided to set up two Command Area Development Authorities, one each for the Ukai-Kakrapara and the Mahi-Kadana Command Area with a view to bringing about expeditious development of these Command Areas. The jurisdiction of the Area Development Authorities will be as shown in Annexure-I. The Area Development Authority will have jurisdiction over an entire taluka even if, only as part of it falls under the Command Area.

2. The composition of the Area Development Authority.

The composition of each Area Development Authority will be as follows :—

1.	Area Development Commissioner.	Chairman
2.	Development Commissioner, Gujarat State.	Member

3.	Chief Engineer, Roads & Buildings and Ex-officio Special Secretary to the Govt., Public Works Department.	Member
4.	Chief Engineer, Irrigation and Ex-officio Joint Secretary, Public Works Department.	,,
5.	Collectors of the Districts included in the Command Area.	,,
6.	Presidents of the District Panchayats of the Districts in the Command Areas, *when in office*.	,,
7.	District Development Officer of the Districts in the Command Area.	,,
8.	Director of Agriculture.	,,
9.	Registrar of Cooperative Societies.	,,
10.	Director of Animal Husbandry.	,,
11.	Settlement Commissioner and Director of Land Records.	,,
12.	Director, Ground Water Investigation.	,,
13.	Representative of the Gujarat Land Development Bank.	,,
14.	Representative of the Gujarat State Cooperative Bank.	,,
15.	Managing Director or his representative, Gujarat Agro-Industries Corporation.	,,
16.	Representative of Gujarat Agricultural University.	,,

3. Functions of the Authority

The Area Development Authority will be generally responsible for drawing up a comprehensive Command Area Development Programme and for supervising its implementation. In particular, the functions of the Authority shall include the following activities :—

(i) Maintenance and efficient operation of the irrigation, distribution system up to the Public Works Department outlet.
(ii) Effective and optimum water distribution beyond the Public Works Department outlet.
(iii) All on-farm development work such as land levelling, land shaping, Kyari making, construction of field channels and field drains etc.
(iv) Development and maintenance of a good drainage system in the Command Area.
(v) Education and training for farmers in irrigated Agriculture.
(vi) Preparing and introducing a scientifically planned cropping pattern in the Command Areas.
(vii) Development of Ground Water to supplement canal irrigation.
(viii) Supply of all inputs and services including credit.
(ix) Planning and Developing processing and marketing facilities especially in the cooperative sector.
(x) Development of Animal Husbandry.
(xi) Consolidation of holdings.
(xii) Special programmes for small farmers, marginal farmers and agricultural labourers in the Command Areas.
(xiii) Development of good network of road.
(xiv) Strengthening the extension activities in the Command Area.

4. Transfer of Activities

The functions listed in para (3), are now being carried out by Public Works Department, Agriculture Department, Cooperative Department, Revenue

Department and District Panchayats. The staff of each of these departments (except that of the District Panchayat) which now execute these activities in Ukai and Kadana Command Areas will stand transferred to the Administrative control of the respective Area Development Commissioner. The Organisations which are thus transferred are listed in Annexure-II. In addition, the following officers of the District Panchayats in the Command Areas will work under the close supervision of the respective Area Development Commissioner :—

1. District Development Officers.
2. District Agricultural Officers.
3. District Animal Husbandry Officers.
4. Executive Engineers.
5. Assistant District Registrar of Cooperative Societies.

5. Powers of the Area Development Authorities (ADAs) and Area Development Commissioners (ADCs).

The ADA will have powers subject to Budget/Plan provisions and policy guidelines issued by the Government from time to time, to take all necessary decisions, regarding implementation of Command Area Development Programmes. The Government may also, from time to time issue such instructions to the Authorities as it may deem necessary for the proper execution of the programmes. All Executive powers of the Authorities will vest in the Area Development Commissioner who will be a full-time officer of the rank of Secretary to the Government in the super-time scale of the I.A.S. He is hereby declared as a Head of the Department and will generally have all powers vested in a Head of a Department from time to time. A specific list of powers of the Area Development Commissioner is attached herewith as Annexure-III. In addition, since proper coordination between District Panchayats and the ADAs is very important, for the work of Command Area Development as, extension machinery, supply of inputs, village roads etc. are functions which the Panchayats perform, the Area Development Commissioner will discharge the functions and have the powers of the Development Commissioner in the respective Command Area.

6. Budgetary Provisions

The budgetary provisions for 1974-75, available with the different Departments for financing the activities now transferred to the Area Development Authorities of Ukai and Kadana—will be placed at the disposal of respective Area Development Commissioners by concerned Administrative Departments.

7. Creation of posts of ADCs and their supporting staff

Two posts in the super-time scale of the I.A.S. (Rs. 2500—2750) are hereby created for the two Area Development Commissioners for Ukai and Kadana respectively. The following posts are also created in each office of the two Area Development Commissioners. The personnel appointed on these posts will function under the administrative control of the respective Area Development Commissioner. All these posts will be temporary and will continue till 28-2-1975.

S. No.	Name of post	No. of posts	Scale
1.	Superintending Engineer	1	1400–1800
2.	Administrative Officer of the rank of a Section Officer (Sachivalaya Cadre)	1	425–850
3.	Stenographer Gr. I	1	350–750
4.	Stenographer Gr. II	1	250–550
5.	Assistants (Sachivalaya Cadre)	2	200–550
6.	Research Assistants (Bureau of Economic and Statistics Cadre)	2	250–550
7.	Clerk	1	130–240
8.	Cashier	1	130–240
9.	Typist	2	130–240
10.	Driver	1	130–240
11.	Peon	3	90–110

The headquarters of the ADA's of Ukai and Kadana will be Surat and Ahmedabad respectively.

8. The estimated expenditure on each ADC and his staff is as follows for 1974-75 :—

Pay of Officers	Rs.	58,344
Pay of Establishment	Rs.	44,640
D.A.	Rs.	15,684
T.A. (Approximately)	Rs.	3,000
Other allowance (C.L.A., H.R.A. etc.) at 15% of pay	Rs.	15,450
Contingencies:		
Non-recurring		
Furniture	Rs.	15,000
Purchase of car	Rs.	25,000
Four typewriters	Rs.	8,000
One Duplicating Machine	Rs.	3,500
Recurring:		
Books	Rs.	2,000
Car Maintenance	Rs.	10,000
Office Rent	Rs.	5,000
Telephone Bills	Rs.	2,500
Stationery	Rs.	5,000
Service Stamps	Rs.	3,000
Electricity Bills	Rs.	1,000
Other contingencies	Rs.	1,500
	Rs.	2,18,618

Say Rs. 2.19 lakhs

The expenditure upto the 31st July, 1974 is expected to be Rs. 93,280 on each office of the two A.D.C.'s as detailed below :—

Recurring expenditure till 31st July on Pay, allowances to contin gencies	Rs.	41,780
Non-Recurring Expenditure	Rs.	51,500
total on each ADC	Rs.	93,280

Total for the two ADC is Rs. 1,86,560.

An amount of Rs. 93,280 each is sanctioned and placed at the disposal of the ADC's Ukai and Kadana respectively to meet the expenditure on the staff mentioned in para 8. This expenditure is to be met by withdrawal from the contingency fund sanctioned *vide* Finance Department Memorandum No. CNF-1174/33-K, dated the 15th May, 1974.

This amount will be recouped and the expenditure on the ADC's and their staff for the period beyond the 31st July, met by necessary provisions in the Supplementary Demands. The expenditure will be debited to the Budget Head.—"308—Area Development—(a)—Ayacut Development—Establishment of Area Development Authorities (Sub-head to be opened)".

This issues with the concurrence of Finance Department on this Department file No. ADA-1073/1564/K.

By order and in the name of the Governor of Gujarat.

Sd/- S. S. WAGH,
Section Officer,
Agriculture, Forests and Cooperation Deptt.

but their use is restricted because of inaccessibility, steep slope, shallow soil etc.

17.1.2 No attempt has so far been made to map out such areas, collate available information and categorise them. Precise data on the extent of land affected by salinity, alkalinity, waterlogging, erosion, etc. are lacking. The land utilisation statistics published by the Directorate of Economics and Statistics (DES), Union Ministry of Agriculture and Irrigation give information on the broad land use classification. Those designated broadly as barren and uncultivated land, culturable waste, and fallow land include large areas which are amenable to reclamation and development. On the basis of long experience of State Governments and other agencies, more well defined categories have been identified in a qualitative sense. Each of these categories has one or more distinguishing characteristics and is amenable to reclamation by method peculiar to it. To these categories belong (a) land infested with shrubs and bushes; (b) ravines; (c) waterlogged lands; (d) lands affected by salinity and alkali; and (e) riverine lands. There are categories of minor importance, such as coastal sandy land, stony and gravelly lands and lateritic soil with thin soil cover. For lands designated as *chos* and *khads,* or those on steep slopes or those affected by shifting cultivation, the problem is one of conservation, permanent agriculture and afforestation. They have been adequately dealt with in Chapter 18 on Soil and Moisture Conservation and Chapter 42 on Production and Social Forestry.

17.1.3 The causes of land deterioration are many but the most important amongst them is the wanton misuse and interference by men and animals. Nature's capacity to maintain ecological balance and conserve her resources against deterioration is considerable, but there is a critical limit, beyond which the rate of deterioration is too great to be checked by nature's own recuperative process. If the interfering influence of men and animals is counteracted in time, that is, before the critical limit is reached, and nature's process is helped by scientific methods of conservation, the original ecological balance may be partially regained. The methods of treatment vary according to the category of the land, and depend on the major factors leading to deterioration. The cost of reclamation and development is dependent on the nature and extent of deterioration. The benefit depends on the level of productivity of the land and to the extent the causes of deterioration are eliminated and the inherent fertility is enhanced and sustained. According to the ordinary norms of economics, the benefit-cost ratio determines the feasibility or otherwise of reclamation methods.

17.1.4 No less important than the development of poor and deteriorated lands for increased agricultural production is the solution of social problems associated with them. It is not by coincidence alone

that, by and large, the poor occupy these lands. Because of this, the problems of reclaiming and developing them have received scant attention. No wonder, therefore, that the deterioration which started at a slow pace has gradually assumed enormous magnitude because of faulty use and lack of any conservation measures. In this long process of neglect some of these affected areas have turned out to be the hideouts of antisocial elements and consequently a menace to the society at large. The task of reclaiming and developing lands in varying degrees of deterioration has, therefore, an added significance. The magnitude of the problem, causes of deterioration and methods of reclamation and development are discussed in this Chapter. The task is admittedly stupendous and as such the implementation of programmes requires appropriate action agency and careful phasing, keeping in mind the priorities. This aspect has been specially emphasised.

2 MAGNITUDE AND CAUSES OF SOIL DETERIORATION AND METHODS OF RECLAMATION

Waterlogged Lands

17.2.1 Precise data on the extent of waterlogged areas is not available but different agencies and research workers have attempted to arrive at certain figures based on sketchy information. On the basis of such information, an area of about 6 Mha is estimated to be waterlogged in the country (Appendix 17.1). In the process of construction of roads, railways, aerodromes, canals and building new townships, the maintenance of natural drainage channels has not received the attention it deserves. Further, without adequate cross drainage works under the roads and railways, the runoff of monsoon rains is obstructed. As a result, water gets ponded upstream of the structures. The introduction of canal irrigation introduces a new dimension in the surface hydrology of the area concerned. Apart from seepage from canals, embankments of the main canals, branches and distributaries offer obstruction to the rain water runoff. Flooding of the valley land by the swelling rivers may cause heavy submergence of the land. Irrigated cultivation without creating proper drainage facilities contributes substantially to waterlogging.

17.2.2 A special committee of the Central Board of Irrigation has defined waterlogging as follows :

> "An area is said to be waterlogged when the water table rises to an extent that the soil pores in the root zone of a crop become saturated, resulting in restriction of the normal

> circulation of air, decline in the level of oxygen and increase in the level of carbon dioxide. The water table which is considered harmful would depend upon the type of crop, type of soil and the quality of water. The actual depth of water table, when it starts affecting the yield of the crop adversely, may vary over a wide range from zero for rice to about 1.5 metres for other crops".

Wheat and sugarcane are affected when the water table is within 0.6 metre; maize, bajra and cotton are sensitive to water table within 1.2 metre; and gram and barley within 0.9 metre.

17.2.3 Based on the depth of water table below ground level as an index, estimates of waterlogged area prepared by various agencies are presented in Appendix 17.1. Of the total waterlogged area of 6 Mha, 3.4 Mha are subject to surface flooding, mostly in the States of West Bengal, Orissa, Andhra Pradesh, Punjab, Uttar Pradesh, Gujarat, Tamil Nadu, Kerala. The remaining 2.6 Mha have high water table.

17.2.4 In irrigated areas it is desirable to keep the average water table well beyond the capillary range, say, around 5 metres if not deeper. Apart from the risk of increasing soil salinity, a high water table is wasteful for groundwater resource as it contributes to unproductive evaporation. Also, a low water table provides more space for groundwater recharge during the rainy season and thus helps in increasing the groundwater resource. In the canal irrigated areas of flat plains of northern India, waterlogging occurs in about one million hectares. The problem of waterlogging is very serious mainly in the irrigated areas of Haryana, Punjab, Rajasthan and Uttar Pradesh. In Punjab and Haryana alone, the area thus affected through faulty irrigation is about 8 lakh hectares.

17.2.5 Waterlogging and its attendant ills in the areas irrigated by the Western Yamuna Canal (Haryana) first received attention around 1850. By 1907, similar phenomena appeared in areas of other canal systems in Punjab. In the Deccan, the Nira Irrigation Project was opened for irrigation in 1884; it caused serious waterlogging and salt affliction in the deep black soils of the command areas. The situation assumed an alarming proportion with 6-7 per cent of the area being damaged annually. The problem of waterlogging was taken up for investigation in Punjab in 1925 when the Waterlogging Enquiry Committee was instituted by the Waterlogging Board which had been constituted earlier. The Chakkanwali Reclamation Farm and the Punjab Irrigation Research Institute at Lahore were established to investigate all the problems associated with irrigation, drainage and salinity. About the same time the Baramati Experimental Station was set up in the Deccan Canal area for a similar purpose. These institutions carried out fruitful research on the nature and properties of waterlogged as well

as salt affected soils and the methods of reclaiming them. In the post-Independence period research on these problems has been intensified and remedial measures taken in several areas, notably in Punjab. In that State, the problem of waterlogging became very acute and the affected area increased from 1.2 Mha in 1955 to 1.6 Mha in 1962 when the water table rose to its peak. Large scale drainage works were then taken up as also sinking of shallow tubewells. The development of groundwater resources in the wake of the introduction of high yielding varieties of wheat helped a great deal in lowering the water table. Between 1966 and 1972, about two lakh tubewells were installed. With these measures the water table has been steadily going down and there is a distinct improvement in the land which had earlier been affected.

17.2.6 A study of the effect of waterlogging on crop production has been recently undertaken covering six areas in Punjab and Haryana where the water table depth is about 1.5 metres below the surface. The study has revealed that the principal *kharif* and *rabi* crops of rice and wheat, particularly the high yielding dwarf varieties are unaffected by waterlogging and salinisation, if sown at proper time. However, crops like maize, bajra, cotton during *kharif* and gram and barley during *rabi* are affected to a considerable extent by waterlogging.

17.2.7 Of the post-Independence major irrigation projects where serious waterlogging and consequent salt problems have arisen, mention may be made of the Chambal project areas in Madhya Pradesh and Rajasthan, the Kosi and Gandak project areas in Bihar, the Tungabhadra areas in Karnataka, Nagarjunasagar areas in Andhra Pradesh, and the Kakrapara project areas in Gujarat. On Chambal project, lack of adequate drainage, excessive drawal of irrigation water in the head reaches and confining irrigation to day time only leaving water to flow from open outlets during the night, led to serious waterlogging. Remedial measures in the shape of land levelling, construction of field channels and field drainage, irrigation during the night also, and avoidance of waste of water have been undertaken in certain areas and have considerably improved the conditions there. In the Kosi and Gandak project areas, water table was already high and the introduction of irrigation with unlined channels and without adequate drainage and proper water courses created waterlogging. Here, from provision of drainage, water courses and field channels, economy in the use of water and exploitation of groundwater to lower the water table are indicated.

17.2.8 Experiences of the past 70-80 years in regard to waterlogging prevailing in the Indo-Gangetic plains caused either by monsoon rains and/or irrigation suggests four methods of remedy. Used singly or in combination according to the situation, reclamation is ensured. These methods are (a) drainage—either surface or subsurface or both—to remove surplus water; (b) lining of canals to prevent seepage

and rise of water table; (c) sinking tubewells and utilising water for irrigation, thereby lowering water table and augmenting recharge of groundwater; and (d) connecting, where possible, high water table tracts with low water table tracts. Drainage is essentially an engineering problem and expert advice is to be sought for satisfactory and economic returns.

Anti-waterlogging measures

17.2.9 In order to determine the most effective method of reclamation of waterlogged lands in tracts of different hydrology, geology and climatology seven pilot projects were set up in Punjab and Haryana in 1960 and studied upto 1967. Each project comprised a large area to serve as an independent unit bounded by a distributary or a drainage channel. These were in Amritsar, Tarantaran, Zira, Fazilka, Sangrur, Sunam, Hansi[1] and Safidon-*cum*-Munak. Observations were regularly made for water depth below the surface, quality of groundwater, crops, their yields, etc. Soil, geological and geophysical studies were also made of the substrata. In each pilot project different anti-waterlogging measures were employed. In certain projects surface drains only were excavated. In others, seepage drains, tubewells and pumping sets were installed. Lining of canals was adopted in certain others. This study has revealed that a combination of measures such as drains and tubewells can effectively eradicate waterlogging. The drainage water is generally fit for irrigation. Instead of wasting it to the rivers and eventually to the sea, it should be utilised as far as possible in the tract itself. The drains should be designed as drainage-*cum*-irrigation channels. Regulators can be constructed at suitable places on the drains to head up water, so that irrigation channels can take off from the drainage channels for irrigating the area in the vicinity of the drains. Such channels and regulators have been constructed on several drains and irrigation carried out successfully. Notwithstanding all the actions which one may take, there would still be areas which remain waterlogged and are liable to flooding. These areas should be identified. For their economic exploitation, they can be brought under suitable crops avoiding flood periods. This aspect has been discussed in chapter 20 on Reorientation of Cropping Systems.

Saline and Alkali Soils

17.2.10 The distribution of saline and alkali soils is quite extensive occurring in almost all climatic zones. These soils occur princi-

1 Now in Haryana.

pally in the following areas :

(i) throughout the Indus valley ;
(ii) valleys and basins of western India ;
(iii) the Ganga valley west of about 80°E longitude ;
(iv) the uplands of the Deccan plateau especially between the Tapti, the Godavari and the Bhima rivers ;
(v) saline marshes of the sea coast and of the deltas of the Ganga, the Cauvery and the Mahanadi ; and
(vi) the coastal salt flats along the Rann of Kutch.

17.2.11 The Natural Resources Division of the Planning Commission conducted a study of wastelands including saline, alkali and waterlogged lands and their reclamation measures. A total area of 6 million hectares of cultivated lands in the country was estimated to be afflicted by salinity and alkali conditions. Abrol and Bhumbla[1] estimated that the total area affected by salinity and alkali was of the extent of 7 million hectares based on the information provided in the report of the Planning Commission and other information available from the States. The distribution of saline, saline-alkali and alkali lands in the States and the districts afflicted by the problem are shown in Appendix 17.2.

17.2.12 Large scale irrigation projects were started in the middle of the nineteenth century and within a few years complaints from farmers started pouring to the revenue authorities on the deterioration of land on account of canal irrigation. As early as 1876, the Reh Commission was set up to investigate into the causes of deterioration of the soils of Uttar Pradesh which had previously been fertile. The problem was later scientifically approached by Dr. Leather.[2] He showed that salts which were formed by the natural weathering of igneous rocks became evident on the surface layers under certain predisposing conditions like (a) arid or semi-arid climate; (b) an impervious subsoil or hardpan; and (c) temporary abundance of humidity in the soil interspersed with dry periods. He designated all such soils by the term 'usar'. The Royal Commission on Agriculture (RCA) put the blame squarely on the failure to provide proper drainage before starting canal irrigation. According to the RCA, drainage survey and drainage construction should form an integral part of all irrigation projects. Usar Reclamation Committee of the erstwhile United Provinces[3] reviewed the technical work done on saline and alkali soils and observed that alkali conditions were mainly due to sodium carbonate and bicarbonate, the exact quantity of which in the soil profile

1 Abrol, I. P. and Bhumbla, D. R. (1971) Saline-alkali soils in India, their occurrence and management. World Soil Resources Report 41, 42-51.

2 Leather, J. W., 1897 Agri. Ledger Nos. 7 & 13.

3 1940. Report of the Usar Land Reclamation Committee, United Provinces, 1938-39.

differed according to the nature of the soil and subsoil such as *Kankar* ($CaCO_3$) beds and high water table. Saline soils which were characterised by the presence of sodium chloride and sulphate but very little sodium carbonate or bicarbonate were smaller in extent than alkali soils. Sporadic work in the characterisation of saline and alkali soils has been carried out in different laboratories and methods of reclamation have also been devised. The methods of reclamation are different for the saline and alkali soils. But no systematic attempt has yet been made to delineate their areas; instead they are mapped together. In some States, the Departments of Revenue have been recording the extent of saline and alkali soils based on visual observations and on 25 per cent lower yields of crops than the normal. The Irrigation Departments of Punjab and Haryana have been taking 20 per cent reduction in yield as the criterion for salt affectation. In some areas information is based on analysis of soil samples taken at 1.6 km grid. In the absence of a systematic survey the areas mentioned in Appendix 17.2 are tentative. In our Interim Report on Soil Survey and Soil Map of India stress has been laid on carrying out standard reconnaissance soil survey throughout the country by use of aerial photographs or Survey of India toposheets in the scale of 1 : 50,000 to map out differentiated soils. In certain cases the use of infrared photographs may be advantageous to monitor subsurface salinity and water table conditions.

17.2.13 Salt affliction in soils may occur due to a variety of causes, viz., (a) capillary rise from subsoil bed of salts; (b) indiscriminate use of canal water; (c) weathering of rocks and the salts brought down from the upstreams to the plains by river water and subsequent deposition along with the alluvial materials; (d) salt impregnated sand blown by sea wind; (e) *in situ* decomposition of soil material and (f) ingress of sea water. Climate, geology, topography and hydrology play either singly or in combination important parts in determining the salt regime of a tract.

17.2.14 As mentioned earlier, saline and alkali soils should be delineated properly because the reclamation methods are different for these two broad classes. Genetically the saline soils are the parent materials from which alkali soils originate. In the process of alkalisation, however, an intermediate class of soils has been identified, namely, saline-sodic. The non-saline alkali or simply the alkali soils are the normal end products of saline soils, but are subject to hydrolysis giving rise to what have been termed degraded alkali soils. The magnitudes of electrical conductivity, which is a measure of salinity, ESP (exchangeable sodium percentage) which is a measure of the extent of sodiumisation of the exchange complex of soil, and pH which measures alkalinity (also acidity) of the four classes of soils are given

in Table 17.1 showing their distinguishing features in terms of the above three parameters. Also indicated in the table are some of the other characteristics of these soils and their reclamation methods. On the basis of detailed mapping as outlined above the reclamation measures become more specific and easy to apply. It is, therefore, suggested that such detailed mapping should be initiated in those areas where reclamation projects are being launched. The cost of reclamation will depend on the method employed.

17.2.15 In the field the problems of reclamation may be more complicated than those of the simple cases mentioned in Appendix 17.2. In some alkali soils otherwise amenable to gypsum treatment, a subsoil clay pan may be formed in course of time, which would hinder drainage. Breaking of the pan layer by suitable physical methods is the only answer in such cases. Again, together with gypsum other amendments like farmyard manure, molasses, pressmud, green manuring etc. alone or in combination could be successfully employed depending on the specific problem of reclamation. A brief account of the work of reclamation of saline and alkali lands might indicate the varied problems that are likely to occur. Reclamation of saline and saline alkali lands through improvement of drainage was tried in Punjab and Uttar Pradesh. In Uttar Pradesh near complete success was achieved in the Chakeri farm near Kanpur in which drainage was effected by mechanical shattering of the hard clay pan in the subsoil using pan breaker attached to heavy tractors. This could shatter clay pan to a depth to 75-100 cm. The ripping was done across the slope at 1.3 metre interval and was followed by bunding and leaching of salts by waters pumped out from the adjoining Ganga. Simultaneously, a crop of *dhaincha* was grown for green manuring purposes. The shattering induced improvement in the infiltration rate and a normal crop of paddy after *dhaincha* was obtained even in the first year of reclamation. Later on the field started receiving sewage water for irrigation purposes which effected improvement in the soil condition. Leaching trials started at the Usar Reclamation Farms at Rahimabad and Katiyar in Lucknow and Dhakauni in Hardoi districts have recorded improvement in the soil condition. A marked drop in soil pH, and exchangeable sodium percentage was recorded in this process and crop yield of almost 2½ times was obtained after a lapse of a ten-year period. Similar leaching trials with Punjab soils were relatively more effective than those in Uttar Pradesh because of the lighter texture of Punjab soils. The technique of reclamation constitutes initial leaching of the deteriorated land followed by rice cultivation. A suitable rotation was then followed which included berseem/senji and sugarcane or wheat or cotton. The heavier saline soils, however, do not respond well to this technique. Reclamation

TABLE 17.1

Classification of Salt Affected Soils together with Their Characteristics.

Class name (local names in parentheses)	$ECx10^3$ at 25° C (millim-hos/cm)	ESP	PH	Other features	Requirements for reclamation
1	2	3	4	5	6
saline (reh; appin soulu, uppu)*	>4.0	<15	<8.5	predominant aniorns : chloride and sulphate; occasionally a little bicarbonate and nitrate; good agregation and water permeability.	leaching and providing drainage adequate.
saline alkali (bari, usar, khar, kshar, lona, chopan, thur, karl, lazni, jougu)	>4.0	>15	<8.5	predominant anions : chloride, sulphate and some bicarbonate and carbonate with occasional nitrate.	gypsum is the most suitable amendment. Acid or acid forming amendments provided alkaline earth carbonates are present.
nonsaline alkali (chodu, bara, kallar, rakkar, phodus)	<4.0	>15	>8.5	predominant anions : carbonate and bicarbonate, largely associated with sodium, dispersed clay and very low water permeability ; columnar structure in the B horizon.	same as in saline alkali
degraded alkali	<4.0	>15	<7.0	the exchange complex is dominated by H+and N+; salts almost completely removed; physical condition almost same as in nonsaline alkali soils.	usually very difficult to reclaim.

* Local names prevalent in different States are mentioned in parentheses.

1 United States Salinity Laboratory Staff (1954) Diagnosis and Improvement of Saline and Alkali Soils, Agriculture Handbook No. 60 United States Department of Agriculture.

trials using gypsum as well as other amendments like FYM, molasses, pressmud, green manure, crop residues and weeds, particularly *Argemone mexicana,* were tried.

17.2.16 Even though a lot of work on reclamation of saline and saline alkali soils has been carried out and a large volume of scientific data are available, no large scale successful reclamation project on saline alkali soils has so far been initiated or is in vogue in the country. This could be attributed either to the immensity of the problem or due to imperfect approach adopted in these ventures. In all these cases, the main emphasis has been placed on yield of crop without much consideration of the improvement in soil conditions. Often even the data on the nature of soils before and after launching the reclamation project have not been collected or reported. This has made the work of evaluation of these projects difficult. Lately, a series of investigations have been initiated at the Central Soil Salinity Research Institute (CSSRI), Karnal and at a number of experimental centres under the Scheme of Coordinated Research on Water Management and Soil Salinity. These experiments are concerned with the application of gypsum on the improvement of soil as measured by yield of crops. Success of any large scale experiments such as these is particularly dependent on availability of good water for continuous cropping, which tends to keep the salts below the rooting zone. The availability of gypsum at reasonable rates is another factor. Consequently, alternative methods using other amendments with or without gypsum should be perfected for adoption on a large scale. The amendments for the reclamation of alkali and saline alkali soils have to have the property of exchanging sodium for either calcium of hydrogen ions. Hydrogen ions are provided by any acid, either sulphuric and organic acids or acid hydrolysable salts like the sulphates of iron and aluminium. Calcium ions are provided by any calcium salt of a strong acid such as calcium chloride and sulphate. The effectiveness of the amendments varies with the nature of the soil, namely, the contents of exchangeable sodium, clay and salts, physical condition of the soil, availability of water for leaching away salts etc. The superiority of gypsum as the cheapest amendment for reclamation of saline-alkali and alkali soils is a proven fact and methods are known to estimate gypsum requirements of soils for field application. Gypsum treatment alone does not reclaim the soil for good. It has to be supplemented with proper crop rotation, post-reclamation agronomy and irrigation to keep leached out salts from coming within the root zone of plants, and to prevent the soil from reversion. The CSSRI has developed several crop sequences suitable for use in reclamation of saline-alkali and alkali soils. Gypsum is available in Bikaner (Rajasthan), Dehra Dun (Uttar Pradesh), Jammu and Gujarat. It has

been estimated that several million tonnes of gypsum can be mined from the Rajasthan quarry alone. In case large scale use of gypsum has to be made for amelioration of the problems of alkali soils in the Northern States of Uttar Pradesh, Punjab, Haryana and some of the Western and Southern States, the mining of agricultural grade gypsum has to be stepped up. The Department of Agriculture in the Ministry of Agriculture and Irrigation has formulated a programme of large scale reclamation of saline-alkali soils in the States of Punjab, Haryana and Uttar Pradesh by use of gypsum. According to CSSRI, 66 per cent gypsum is a suitable agricultural grade, the cost of which varies from Rs. 15 to 18 per tonne at the quarry site. The major components of cost are, however, grinding, transport and packing. Taking all these factors into account the sale price in bulk may be around Rs. 70 per tonne. Calculations show that this price is not prohibitive in the context of the benefits accruing from reclamation. However, a suitable subsidy may be given to small and marginal farmers owning alkali affected lands for the purchase of gypsum for reclamation. It would be worthwhile to take up suitably large scale reclamation projects in order to prevent infestation of salts from neighbouring areas. As already mentioned, for sustaining the soils in productive conditions after reclamation and preventing reversion, adequate supply of good quality water is needed so that the reclaimed land is kept under continuous cropping. Lack of water can be a real constraint in reclaiming saline and alkaline lands, especially in low rainfall areas where they generally occur. During reclamation, changes in physico-chemical characteristics of the soil have to be periodically observed to enable modifications, if any, of reclamation measures.

Land Infested with Shrubs and Bushes

17.2.17 In the land utilisation statistics a category of the above has not been differentiated and as such no reliable data on the extent of area under shrubs and bushes are available. Such areas are a part of wastelands on which several surveys have been carried out. In reply to a questionnaire issued by the Commission to different States only four have reported the extent of area under shrubs and bushes as shown below:—

	Area (hectares)
Karnataka	317,000
Kerala	27,800
Madhya Pradesh	687,000
Mizoram	6,700

No other State appears to recognise such problem lands as a separate category even though there are large areas in Uttar Pradesh, Bihar, West Bengal and some other States where such infestation exists. The main reasons for such lands remaining unutilised are deep rooted grasses and weeds, unhealthy conditions, lack of drainage, low fertility of the shallow soil, lack of water supply, salinity and alkali conditions, damage by wild animals and severe erosion. In the post-Independence period, some of these lands have been reclaimed by tractorisation and made to yield good crops by means of good farm management practices.

17.2.18 At the Indian Grassland and Fodder Research Institute, Jhansi and soil conservation research centres of the Indian Council of Agricultural Research (ICAR), appropriate technology has been developed to establish rangeland or fuel/fodder reserves in such degraded lands. Pilot operational research projects on watershed basis covering 2000-3000 ha need to be taken up to test the economic feasibility. Standard soil survey should be carried out to delineate different land capability classes suitable either for cultivated crops or grasses or forest plantations. Use of tractors on these difficult lands and terrain is attended with high cost and unfavourable benefit-cost ratio especially at the initial stage but in the long run, good management can make these lands economically viable.

Ravines

17.2.19 Extensive degradation of land has occurred in Uttar Pradesh, Madhya Pradesh, Rajasthan and Gujarat along the banks of the rivers of north-central India, namely, the Yamuna, the Chambal, the Mahi, the Sabarmati and their tributaries. There is no historical record to show when the deterioration started but it is reasonable to assume that indiscriminate use of land leading to disturbance of the ecology has been one of the reasons for this degradation. Erratic, short duration and high intensity rainfall, loose and friable nature of the soil, steep slopes and undulating terrain, faulty agricultural practices, illicit cutting of trees and bushes, grazing of lands and similar biotic interference have combined to aggravate the situation, ultimately resulting in deep gullies, commonly known as ravines. High flood level has contributed to the deepening and widening of the ravines. The rivers in high floods back up into the ravines, and hasten soil slipping. Prolonged inundation causes damage to protective vegetative cover. Ravine formation has removed fertile cultivable lands along the river banks of the region. The process once started continues with increasing speed.

17.2.20 The Planning Commission[1] published in 1965 a study on survey and reclamation of ravines in India. More recently, under the auspices of the Ministry of Home Affairs, Government of India, a Working Group was formed to review the ravine problems in the country and to formulate a programme of ravine reclamation. This Working Group has made a comprehensive study of the problem and estimated the extent of ravines[2] in the different States as indicated below:

	Ravine area (Lakh hectares)
Uttar Pradesh	12.30
Madhya Pradesh	6.83
Rajasthan	4.52
Gujarat	4.00
Maharashtra	0.20
Punjab	1.20
Bihar	6.00
Tamil Nadu	0.60
West Bengal	1.04
TOTAL	36.69

In the report of the Working Group the districtwise and riverwise distribution of the ravine lands in Uttar Pradesh, Madhya Pradesh and Rajasthan has also been given. In Gujarat, the ravine affected lands exist in North, middle and South Gujarat and the districts affected are Baroda, Kaira, Sabarkantha, Banaskantha, Mehsana, Ahmedabad, Panchmahal, Broach, Surat and Bulsar. The ravine lands in Gujarat have been categorised on the basis of ownership, *e.g.*, privately owned ravine lands (60 per cent), Panchayat gauchar land (21 per cent) and Government owned ravine lands (19 per cent). In other States the ravine problems are not as acute as in Uttar Pradesh, Madhya Pradesh, Rajasthan and Gujarat.

17.2.21 The earlier efforts of ravine reclamation have been in the nature of (a) forest plantations of economic species; and (b) development of fuel/fodder reserves. Successful examples of these measures can be found in 'Fisher Forests' Etawah (Uttar Pradesh), which were developed in the latter half of the nineteenth century. The afforestation of Gwalior (Madhya Pradesh) ravines in the early twentieth century is another example. During the early plan periods (1954-55), systematic research on soil and water conservation in

1 1965. Study on Survey and Reclamation of Ravines in India, Planning Commission, Government of India, New Delhi.

2 1972. Report of the Working Group on Ravine Reclamation, Ministry of Home Affairs, Government of India, New Delhi.

ravine lands has been emphasised. A chain of regional soil conservation research centres has been established by the Central Government and three of them, being located in the ravine areas at Agra (Uttar Pradesh), Kota (Rajasthan) and Vasad (Gujarat). On the basis of work done at these centres, the ravines of these areas have been classified as under[1]:

	Specification		
	Depth (m)	Bed width (m)	Side slope %
very small and small gullies	..	18	varies
medium gullies	< 3	18	8–15
deep and narrow gullies	(a) 3–9	18	varies
	(b) 7–9		moslty steep; varies

Pilot schemes on a watershed basis have also been taken up mainly in the nature of terracing land to be reclaimed with suitable drainage works. Whereas such work may be economical and suitable in areas with small and medium gullies, in deeper ravines involving heavy earth movement the cost will be prohibitive. The strategy for handling these deeper ravines has been laid down by the Ministry. The plateau and top areas of these deep ravine zones are reclaimed for cultivation making suitable soil conservation and water drainage arrangements on the fringes. Similarly, the valleys of the ravines including raised areas are suitably levelled for cultivation. The slopes of the ravines are used for forest and fodder development. The suitable species of timber, fuel and fruit trees in use are *ber* (*Zizyphus spp.*), drum stick (*Moringa pteriqosperma*), *khair* (*Accacia catechu*), *sissoo* (*Dalbergia sissoo*), *siris,* (*Albizzia lebbek*), etc. At the Soil Conservation Research Centre, Vasad (Gujarat), successful plantings of lemon and bamboo in *kotar* lands have been possible. The Working Group of the Ministry of Home Affairs has estimated in detail the cost of reclamation of some of these ravine areas as indicated in Appendix 17.3.

17.2.22 The problem of ravines has assumed urgency because they are fast spreading into cultivated lands. In Madhya Pradesh alone, 700 hectares of good table land is degenerating into ravines every year. This deterioration has affected not only the agricultural land but also habitations, roads, railways and other public properties. The other problem is the presence of antisocial elements in the ravines which provide escape routes and hideouts for the dacoits. The

1 1973. Bulletin of Indian National Science Academy, No. 44, p. 162.

active erosion problem in ravine lands needs to be seen in the background of the economic loss apart from social considerations mentioned above. It has been estimated that the production potential of ravine areas in Uttar Pradesh, Madhya Pradesh and Rajasthan alone would amount to 3 million tonnes of foodgrains annually. In addition, fruits, fodder, fuel, timber and industrial raw materials can be produced. On a conservative estimate the country is losing a total output worth about Rs. 157 crores a year by failure to reclaim and develop the ravines.

17.2.23 The estimate of ravine lands given in paragraph 17.2.20 is not based on systematic survey and as such there is an urgent need to carry out standard soil survey in these areas for the purpose of differentiation of the various soils and classes of ravines and mapping them in a suitable scale. For whatever areas aerial photographs are available, they should be interpreted to find out the extent, vegetative cover and other physical features, characterising a particular ravine system. Where aerial photographs do not exist urgent steps should be taken to photograph those areas in the scale of 1 : 15,000. Photointerpretation will help classification and delineation of areas needing priority treatment.

17.2.24 The Royal Commission on Agriculture had recognised ravine problem to be of special significance and suggested that continued afforestation of the ravine tracts should be taken up as the main remedy for soil erosion. The Government of India constituted a Central Ravine Reclamation Board in 1967 to ensure ravine control on proper lines and a more rapid development of the areas. The national policy on reclamation of ravine lands consists of two broad objectives, namely (a) to arrest further growth of the ravines and save the valuable tablelands above: (b) to utilise the already reclaimed land for productive purposes whether for cultivated crops, grasses, horticulture, forestry or industrial raw materials depending upon land capability and the practical considerations of social and economic conditions. For the purpose of tackling ravine problems the following aspects received consideration :

(i) survey and planning ;
(ii) ravine classification and land use ;
(iii) ravine stabilisation ;
(iv) land rights and transfers ;
(v) social problems; and
(vi) operational research and evaluation.

17.2.25 The Board with two sub-committees for Madhya Pradesh and Rajasthan sponsored schemes of pilot projects for ravine reclamation for agriculture and afforestation. During the years 1970-71 and

1971-72, a total of 3,300 hectares were reclaimed in these pilot projects in Madhya Pradesh, Uttar Pradesh, Rajasthan and Gujarat and during 1972-73 reclamation of 2,000 hectares was projected. The progress of State sector schemes of ravine reclamation is presented in Table 17.2

TABLE 17.2

Ravine Reclamation since First Plan upto 1970-71 in the State Sector Schemes[1]

(thousand hectares)

	Ravine reclamation for agriculture	Ravine afforestation	Total
Uttar Pradesh	..	23.75	23.75
Madhya Pradesh	3.10	5.98	9.08
Rajasthan	..	3.69	3.69
Gujarat	0.78	12.42	13.20
TOTAL	3.88	45.84	49.72

In reply to our questionnaire only Gujarat has provided data on the progress of ravine reclamation from the Third Plan to the end of the Fourth Plan as shown below :

area surveyed ('000 ha)	287.7
area reclaimed for	
(i) agriculture	30.9
(ii) afforestation	18.5
expenditure (Rs. lakhs)	365.7

17.2.26 The methods of reclamation adopted by different States are as follows :

Gujarat: Ravine areas are treated on watershed basis ; the table lands upto 3 per cent slope are bunded and good conservation farming practices are followed ; the marginal areas are reclaimed and stabilised with soil conservation measures like diversion bunds, contour and peripheral bunds with suitable drop structures for surplus water disposal ; the ravine areas are reclaimed for agriculture, horticulture, pasture development and afforestation according to land capability classes.

Uttar Pradesh : Shallow and medium ravines are reclaimed for agricultural purposes; after detailed survey the terraces of suitable width are developed and the interspaces are levelled with suitable grading ; proper masonry and grass outlets

1 Report of the Working Group on Ravine Reclamation, Government of India, Ministry of Home Affairs, New Delhi, October, 1972, pp. 25-26.

are provided to drain out the excess runoff; these operations are done both mechanically and by manual labour; after the mechanical operations suitable agronomical practices are followed, horticultural crops are raised with suitable provision of contour bunds with necessary grades; reclamation of deep ravines for agricultural or horticultural purposes not being economical, this is usually put to grass and forest development. Check dams and gully plugs are provided with suitable outlets mainly in the form of grassed waterways.

Madhya Pradesh: After initial detailed survey, shallow ravines are treated with measures like easing of slopes, levelling of hillocks, construction of diversion bunds, engineering structures, gully plugging, irrigation channels and water drainage, deep ravines are tackled by the forest department for the purpose of afforestation and stabilisation.

Rajasthan: The medium ravines are fenced for protection against biotic interference; diversion bunds of 700 metres long are provided at distance of twice the depth of the ravine with a cross section of 1.7 sq. metre; this completely diverts the runoff which otherwise cuts further the active gully heads; the runoff so developed is safely disposed of by means of spillways; the steep ravine heads are stabilised by sloping in the ratio of 1 : 1 which helps establishment of good cover.

17.2.27 Gujarat has attached great importance to *Kotar* lannd reclamation, to transfer it from a wasting asset to a valuable one. *Kotar* villages are mostly agricultural. Dairying is practised as a complementary vocation and raising grass is of paramount importance. The land use in *Kotar* is mixed afforestation *i.e.*, establishment of an orchard-grass-tree system.

17.2.28 It is of utmost importance to subdue the effects of runoff in the watersheds of the various ravines. It is imperative to tackle the watershed beginning from the water divide line to the confluence of the ravine with the main river. Unless the whole of the watershed is treated including the ravines from the gully head to the bottom, isolated works would be in danger of being washed away and lead to no benefit. Land ownership boundaries and individual field boundaries would come in the way of scientific planning of ravine land reclamation. It is, therefore, necessary that land consolidation and settlement operations are simultaneously undertaken. Planning should be done without regard to property lines and the project executed keeping the interest of the area as a whole. The redistribution of the

owned property may be done giving full consideration to various types of measures taken and the ultimately prepared benched terraced cultivable lands. Areas considered suitable for horticultural purposes should similarly be planned on contours and redistribution done in such a way as to cause minimum interference in the management of not only irrigation water but also in planning and controlling the runoff of rain water. Even the areas unsuited for raising food and horticultural crops and recommended for forestry should be subject to runoff management.

17.2.29 The cost of reclamation of ravine lands varies according to the item of work undertaken. In Gujarat the cost of construction of composite check dam has been reported to be about Rs. 672 per unit and the cost of terracing around Rs. 1,000 per hectare working out to an average cost of Rs. 1,875 per hectare. In Uttar Pradesh, the cost of reclamation by mechanical means comes to about Rs. 5,000 per hectare and through manual labour nearly half the amount. Afforestation cost varies from Rs. 442 to Rs. 740. With the rise in prices, the present reclamation cost per unit area is likely to be higher. The affected States have, however, indicated that the reclaimed land is valued many times more than the original cost of the ravine land, and reclamation is likely to be economical. Madhya Pradesh has indicated that the net profit after making allowance for maintenance, depreciation, interest etc. comes to about Rs. 1,500 to Rs. 2,000 per hectare. The economic benefits should not be the sole consideration in the reclamation of ravines. Poverty is rampant in the area and has to be banished. Besides, the anti-social elements inhabiting the area and disturbing peaceful living in the neighbouring countryside require to be transformed into social beings and peace in the region restored. At present hundreds of habitations and their valuable tablelands are threatened with marching ravines which are taking a toll of about 8,000 hectares of valuable agricultural land every year costing nearly Rs. 4 crores. In view of the above, ravine reclamation should receive national priority and the investment should not be denied on account of narrow or unfavourable benefit-cost ratio. The Working Group of the Ministry of Home Affairs has made a perspective plan for ravine reclamation with which we are in full agreement.

Riverine Land

17.2.30 The heavy sediment load carried by rivers in India and steep slopes they have to negotiate cause meandering action and serious bank erosion. This is especially so with the rivers originating

in the Himalayas. Fertile areas with flourishing crops, orchards, towns and cities on the banks of the rivers are often eroded by meandering Streams. Depending on the course of the rivers and the speed of flow, they deposit large quantities of sediments on way to the sea. Gradually land masses are formed which remain for some part of the season at least above the flood level. Such riverine lands are called *Khadar* in North India, *Diara* in Eastern Uttar Pradesh and Char in West Bengal. It has been estimated that about 15 and 9 lakh hectares of such lands occur in Uttar Pradesh and Bihar respectively. These lands run along the river course but their width varies with the flow characteristic of the rivers. The Kosi river, for example, before the embankments were constructed, continued to shift its course in a wide belt. The areas under riverine lands can be reclaimed by canalising the river flow. Sutlej river, for instance, has a wide stream-bed of 8 to 10 km. in width. During 1962—65, embankments were constructed and the Sutlej river, in this vulnerable stretch, has been canalised to confine its flow to a narrow channel, reclaiming thereby one lakh hectares for cultivation. Another example is the Beas riverine land. Here the flood embankment has been constructed, reclaiming thereby about 25,000 hectares of riverine wasteland for cultivation. Constructing similar embankments on vulnerable stretches of the rivers Ravi and Jumna, 25,000 to 30,000 hectares of riverine wastelands can be brought back to profitable cultivation. Other examples are Patiala Ki 'Rao' and Janta Devi Ki 'Rao' (Khankot Nadi). They used to flow through the districts of Ambala, Patiala and Sangrur, and then joined Ghaggar river. These 'Raos' have since been diverted into the Sutlej river via Siswan. In consequence, large areas of land formerly lying under water on both sides of these 'Raos' and also the stream-bed are gradually being brought under cultivation. Such areas on each 'Rao' are estimated to be at least 12,000 to 15,000 hectares. Further, Jhambowali 'cho' which rises from the spills of Patiala Ki 'Rao' and Janta Devi Ki 'Rao' would now become a tiny local drainage channel releasing about 10,000 hectares of its former bed, which can be brought under plough. In view of the above facts, it is recommended that in multiple channel rivers occupying vast areas under their beds, the subsidiary channels should be diverted, wherever feasible, into the main river and the land under the bed be reclaimed for profitable land use. It is further recommended that rivers on which dams have been constructed to effect flood moderation, the canalisation of such rivers may be effected downstream of the dam, wherever feasible, in bringing back large areas of riverine wastelands for profitable land use.

17.2.31 Huge sediment load is carried by hill torrents called the

'chos', emanating from the Shiwaliks. These sediments get deposited when the 'cho' emerges in the plains where the 'cho' divides and subdivides and ultimately disappears after about 20—25 km from the foothills. In the course of such actions, 'chos' deposit thick blankets of coarse debris, sand etc. over the green fields. Such devastations of 'cho' in Punjab alone have affected about 2.5 lakh hectares of fertile land. Out of this, 1.8 lakh hectares occur in Hoshiarpur district alone. There are about three lakh hectares in all under 'chos' and 'khads' mostly in the districts of Hoshiarpur of Punjab, Ambala of Haryana and Kangra of Himachal Pradesh. The 'cho' damage is on the increase every year. In 30 years' time, from 1850 to 1880, the area damaged by 'chos' in Hoshiarpur district alone increased from 20,000 to 35,000 hectares. Various 'chos' of the 'Katar Dhar' range in Hoshiarpur district have, however, been canalised by suitably training these hill torrents around Hoshiarpur city for its protection. It is therefore recommended that wherever feasible, the technique and experience already available in grouping 'chos' (hill torrents) for their canalisation and reclaiming the 'cho' devastated land for better land use should be adopted extensively.

Coastal Sandy Land

17.2.32 India has a long coast line of about 5,600 km. Sea and wind erosion, specially during the monsoon, is serious and extensive. The problem is acute mostly in the eastern coast of Orissa and western coast of Kerala. Apart from the injuries of saline sea wind, the shifting coastal sand causes serious damage to agriculture. Annually, fertile good land suffers from blown sand. Coastal erosion involves intimate knowledge of the physics of sea and oceanography. At the global level, USA has carried out intensive work in this field, but it is comparatively a new discipline in India. A research unit on the lines of the 'Beach Erosion Board' of USA has already been set up to study sea erosion in Kerala coast to develop suitable control measures.

17.2.33 There are large areas along the coastal line lying under the sand dunes, especially in the coastal districts of Tamil Nadu, Maharashtra, Gujarat and Orissa. The area under coastal sand dune is on the increase and the blown sand causes serious damage to the standing crops in its neighbourhood. The menace of blown and shifting sand in the coastal area intensifies during the cyclonic periods if the vegetative cover is poor or nil. Plantation of *Casuarina* on the sandy foreshores backed by coconut, cashewnut and Eucalyptus further inland can considerably minimise the problem of blown sand, as Tamil Nadu experience has shown.

17.2.34 Extensive coastal sandy areas which are partly saline are lying unutilised along the long coastline. The problem occurs in varying degrees of complexity in West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Maharashtra and Gujarat. The eastern and south-western coastal areas receive moderate to high rainfall, whereas the rainfall is low with an arid type of climate in Gujarat coast. The area affected is roughly estimated to be between 50 and 80 thousand sq. kms., at least about half of which is amenable to reclamation. Here also, plantations of *Casuarina*, eucalyptus and coconut would be useful. We, therefore, recommend that using available technology, plantations of *Casuarina,* eucalyptus, coconut, cashew, *chikku,* etc. should be taken up extensively for profitable land use and controlling erosion in the coastal tracts.

Stony and Gravelly Lands

17.2.35 Such lands lying waste are normally found on rolling topography and plateaus which have been subjected to heavy grazing or indiscriminate felling of trees. Lying without adequate vegetation, they are severely eroded. Soils in such lands are generally acidic and can be made productive by liming. It is, therefore, recommended that stony and gravelly lands should be closed to grazing for a few years for establishing good vegetative cover before controlled grazing is allowed.

Lateritic Soils

17.2.36 Extensive areas of land measuring about 12 Mha and consisting of lateritic soil have been identified in Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Orissa, Bihar and West Bengal. These are highly leached ferruginous soils, poor in fertility, low in water retentivity and high in phosphatic fixation. As the soil depth becomes shallow, soil-plant-water relationship becomes precarious for successful establishment of vegetation. There is possibility of growing certain trees and grass etc. in these areas but no extensive attempt has been made in this direction.

High Altitude, Steep Slopes and Meadows

17.2.37 Extensive areas occur on high altitude over steep slopes or as overgrazed meadows, specially in the Himalayan region. Serious soil erosion takes place there under injudicious land use. They constitute the spots which contribute most to the heavy silt discharges from

the Himalayan watersheds and thereby endanger the life of multipurpose reservoirs. Urgent measures, therefore, need to be taken to put such areas under permanent cover of suitable grasses and trees. In view of difficult terrain and accessibility, practically no effort has been made to revegetate such landscapes on the high altitude and on steep slopes. Similarly, valleys in higher elevations with peaty soils have not yet been fully utilized. Success achieved in the high-altitude agronomy at Leh farm has opened up avenues for further research and development leading to higher agricultural production in such areas. Similar attention needs to be paid for increasing production from alpine pastures and meadows.

3 REVIEW OF WASTELAND RECLAMATION AND UTILISATION

17.3.1 The problem of reclamation and utilisation of wastelands is complex. Some of the causes of the origin of wastelands are overgrazing and indiscriminate cutting of forest trees which upset the ecological balance. Once the cover is destroyed, soil erosion starts and later on it takes many years and much capital investment before the land is restored to economic use. The wastelands, if properly treated and managed, will supply valuable fodder for cattle fuel for the villagers and raw material for industry. Development of such nonarable land resources will thus develop rural economy including agricultural, animal husbandry and industrial activity. The conservation and development of wastelands requires a close cooperation of the State Forest and Revenue Departments and the local community which has been lacking hitherto. We, therefore, recommend that the causes detailed in earlier Sections, which contribute to the formation and deterioration of wastelands should be examined by the concerned State departments in order to chalk out a right strategy for its reclamation. This will prevent more land going waste and reclaimed lands from losing their productivity. We also recommend that schemes for development and utilisation of the wastelands should be formulated jointly with the Forest Department, the Revenue Department, the *Zila Parishad* and similar institutions.

17.3.2 In June, 1959, the Government of India constituted the Wasteland Survey and Reclamation Committee to make a survey of the land classified as "Other uncultivated land excluding fallow lands" and "fallow lands other than current fallows" and to locate areas where large blocks of land in areas of more than 100 hectares

are available for reclamation and resettlement and to suggest suitable measures for these purposes. The Committee conducted a detailed survey of 12 States, viz., Punjab (including Haryana), West Bengal, Bihar, Karnataka, Andhra Pradesh, Madhya Pradesh, Kerala, Tamil Nadu, Uttar Pradesh, Jammu & Kashmir, Maharashtra and Gujarat. In these States, the area of wastelands available for cultivation in blocks of 100 hectares or more is reckoned at nearly 6.4 lakh hectares[1], as detailed below :

	thousand hectares
Punjab (before reorganisation)	121.86
West Bengal	45.46
Bihar	35.46
Karnataka	47.33
Andhra Pradesh	75.57
Madhya Pradesh	102.05
Kerala	22.37
Tamil Nadu	15.39
Jammu & Kashmir	5.17
Uttar Pradesh	124.64
Maharashtra	17.21
Gujarat	28.43
TOTAL	640.94

The existing data are not, however, sufficiently reliable and lands classified as culturable waste at the time of settlement often continue to be shown as such in the revenue records, long after they have come under cultivation. The Committee noted that the data under the head "culturable waste" serves little purpose but detailed information should be available about the type of wastelands in each State, the ownership of such lands, their availability in sizeable blocks and the cost of reclamation measures envisaged. The Committee has recommended that rapid reconnaissance survey should be conducted for factual information.

17.3.3 A Centrally sponsored scheme was started in August, 1971, for carrying out surveys of wastelands in blocks less than 100 hectares in the States. In locating and surveying wastelands for agricultural use, the important factors for consideration were : depth of the soil, availability of irrigation water, erosion factors and slope of the land. The extent of culturable wastelands in blocks of less than 100 hectares identified as suitable for cultivation after reclamation upto March 31, 1969, is about 2.3 Mha in different States, as given in Table 17.3.

1 1975. Land Statistics of India, Soil Conservation Division, Ministry of Agriculture and Irrigation, New Delhi, p. 53.

TABLE 17.3

Culturable wasteland in blocks of 5 ha and above upto 100 ha[1]

(thousand hectares)

State	Area located
Assam	133
Bihar	77
Gujarat	174
Himachal Pradesh	1
Karnataka	180
Kerala	83
Madhya Pradesh	928
Maharashtra	157
Orissa	130
Punjab	59
Rajasthan	266
Tamil Nadu	27
Tripura	54
Uttar Pradesh	19
West Bengal	8
TOTAL	2,296

17.3.4 The ultimate aim of the surveys mentioned above is to find suitable use of these lands for cultivation, or growing grass, pastures, afforestation, etc. To meet this objective the survey of wastelands must provide the necessary information. There are large areas of wastelands which, under present conditions, are not cultivable due to certain limitations but could be brought under the plough with suitable reclamation measures. It is, therefore, necessary to categorise the culturable wastelands according to the feasibilities of reclamation within economic means. It is imperative that the reports of the Statewise survey and categorisation of wastelands are examined for the purpose of utilising them in accordance with their capabilities bearing in mind at the same time the local demand for grass, pasture, fuel, fodder and small timber along with food crops. In this connection we refer to paragraph 17.3.9 and 17.3.10 below and to our Interim Report on Social Forestry, wherein we have recommended that wastelands in compact blocks of 20 ha should be brought under mixed forestry, for instance, for raising grass and leaf fodder, fruit trees and fuelwood trees. The categorisation of all wastelands in the country in blocks less than 100 hectares should be completed as a Centrally sponsored scheme on a priority basis. We recommend that the use of aerial photographs and remote sensing techniques for survey of wastelands should be adopted. The interpretation of the aerial photographs and that of soil survey reports of wastelands should conveniently

1 1975. Land Statistics of India, Soil Conservation Division, Ministry of Agriculture and Irrigation, New Delhi, p. 61.

be done on a uniform basis. We are of the view that during the soil survey of wastelands, data on water table should be collected and compiled since these data would help in better and more economic utilisation of land.

17.3.5 Land is lying waste along railway lines for which no systematic records are maintained. It calls for some organised action. We feel that extensive areas lying unutilised or underutilised along the railway lines, national highways, rivers, canals, etc. should be surveyed and utilised, after reclamation where necessary according to land use capability. For effective implementation of any action programme based on such surveys, it would be necessary to have a coordination committee consisting of representatives of the concerned Ministries/departments at the Central level.

17.3.6 The planwise progress of land reclamation for resettlement is detailed below :

	(million hectares)
First Plan	1.13
Second Plan	0.93
Third Plan	1.82
1966-67	0.12
1967-68	0.14
1968-69	0.16
1969-70, 1970-71, 1971-72	0.16
1969-74 (target)	0.365
TOTAL (anticipated)	4.665

Wastelands which belong to Government are allotted mostly to landless agricultural labourers and ex-servicemen who have the necessary background in agriculture. These people do not have the financial resources which are required for the reclamation of wastelands. During the Third Five Year Plan, schemes to resettle 3.31 lakh families were approved by the State Governments. Out of the above, till the end of the Third Plan and upto March 31, 1969, a total number of 1.11 lakh families were resettled as per statewise details given in Table 17.4.

TABLE 17.4

Progress of Reclamation of Wastelands and Resettlement of Landless Agricultural labourers (upto March 31, 1969) [1]

State	Area reclaimed and allotted (in hectares)	Families resettled (number)	Expenditure incurred (Rs. lakhs)
1	2	3	4
Andhra Pradesh	3,230	3,362	7.80
Assam	380	441	8.75

1 1975. Land Statistics of India, Soil Conservation Division, Ministry of Agriculture and Irrigation, New Delhi, p. 62.

1	2	3	4
Bihar	19,290	16,175	23.00
Gujarat	19,647	7,699	80.97
Karnataka	145	140	14.06
Kerala	8,451	4,367	29.75
Madhya Pradesh	31,811	12,174	80.47
Maharashtra	50,415	20,361	237.72
Orissa	674	360	6.20
Punjab	44,557	40,039	2.81
Tamil Nadu	7,179	2,862	117.54
Uttar Pradesh	3,131	2,892	5.78
Tripura	827	892	Nil
West Bengal	91	NA	NA
TOTAL	1,89,832 Or two lakh hectares approx.	1,10,754	614.85

NA—not available

While distributing wastelands to the landless agricultural labour, ex-servicemen, etc. provision for necessary inputs to undertake cultivation and scientific reclamation, viz. agricultural implements, improved seeds, pesticides, irrigation and credit facilities should be made by the Government.

17.3.7 Financial assistance to the extent of Rs. 750 per family for the initial resettlement of landless agricultural families has been given by the Government of India in the pattern of 75 per cent as grant and 25 per cent as loan. The expenditure on land reclamation is borne by the Centre and the State Governments on 50 : 50 basis, subject to a maximum of Rs. 750 per hectare. For bringing wastelands under cultivation heavy investment on land levelling, soil conservation and irrigation etc. is needed. The average cost of land reclamation, where only jungle or shrubs are to be cleared and deep ploughing is to be carried out, comes to about Rs. 250 per hectare. In the areas where land reclamation operations include soil conservation measures, levelling of land in addition to clearing the land and preparation of the seed bed, the cost of land reclamation comes to about Rs. 750 per hectare. The cost of reclamation of *Khar* lands comes to about Rs. 1,250 per hectare in Gujarat and Maharashtra where large bunds up to 18.6 sq. metres cross-section have to be constructed against ingress of sea water, drainage facilities to be provided and soil amendment applied. The cost of land reclamation operations in places where the percentage of slope is very high and terraces have to be constructed varies from Rs. 1,750 to Rs. 2,000 per hectare. The

cost of reclamation of shallow ravine lands ranges from Rs. 750 to Rs. 1,000 and that for medium ravines Rs. 2,000 to Rs. 2,500 per hectare. The cost of reclamation has gone up these days appreciably. However, this, by itself, is not prohibitory when it is compared with the current market price of the land as well as that of the produce from these lands. In the earlier times when the cost of agricultural produce was low, the reclamation cost appeared to be relatively high but the same is not true under the present conditions.

17.3.8 The problem of building up soil fertility on newly reclaimed lands is a complex one. Where the initial fertility of the soil has been high because of high organic matter content in the upper layers, the production in the first one or two years will be high. Soil fertility in such lands can be maintained by adding organic manures chemical fertilisers and by adopting suitable cropping patterns. There are lands where the initial fertility of the soil is low. There are others the fertility of whose soils goes down due to exposure of the subsoil during land reclamation operations. The soil fertility in such lands can be improved by (a) growing green manuring crops like sunnhemp, guara, dhaincha, etc. in suitable cropping patterns, (b) use of heavy dosages of organic manures and fertilisers, (c) application of amendments as required. In the reclaimed areas the yield per hectare is quite comparable with that obtainable from the adjoining lands already under cultivation. The general observation is that if adequate fertilisers are added and improved practices adopted from the very beginning, the yield of these lands can be sustained at a good level. It is essential that necessary soil conservation measures are taken up at the time of reclamation of these wastelands and that such measures are maintained, otherwise the productivity will go down due to erosion and other causes.

17.3.9 The poor vegetation in the wastelands is the result of continued maltreatment of soil and neglect of the vegetative cover as a result of annual fires, overgrazing, repeated lopping or cutting of trees and shrubs. The problem of afforestation of wastelands is important from the point of view of not only improving the productivity of these areas but also from that of arresting their further deterioration. The species of plants and trees suited to the climatic zone[1] and resistant to the various adverse soil conditions have a good chance to establish, if biotic interferences are reduced. Soil characteristics of wastelands, viz. shifting sand dunes in desert areas, saline and alkali soils, ravine lands, skeletal and rocky soils, denuded hill slopes, coastal sands, heavy black soil with or without 'Kankar' pans and waterlogged areas will decide the plant species which can be grown. Afforestation of waste-

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1 T. N. Srivastava and J. M. Qureshi (1972). Suitability of Trees and Shrubs for Wastelands Reclamation—Bulletin, Indian National Science Academy, No. 45; pp. 72-81.

lands with fast growing species could be helpful in converting large areas of such lands for other useful purposes. In the earlier stages of development, afforestation of such wastelands should, therefore, be considered from the larger perspective of utilisation for protective purposes rather than for purely financial returns.

17.3.10 There is an urgent need for attaining self-sufficiency in fodder, fuel, small timber and wood for pulp. In this context, country's wasteland or unutilised land offers great scope. We, therefore, feel that the reclamation of wasteland may be planned to meet the above demands of national importance. It is further recommended that the scheme for land reclamation and development, although transferred to the State sector from the Fourth Plan should be treated as a Centrally sponsored scheme in future plans so as to attract more concerted attention. Development of pastures in wastelands is intimately connected with the development of livestock industry. No improvement of the wastelands is possible unless they are protected from unplanned use by men and animals. The carrying capacity of the grasslands may be increased by developing pastures sown with high yielding grass species. It is recommended that in the wastelands, not suitable for soil working and sowing of high yielding grasses, the fodder resources may be developed suitably in a few years' time by fencing and protection against grazing beyond their carrying capacity, and by introduction of rotational grazing. To enable the livestock industry to develop faster than hitherto in hilly and desert areas, development of pastures should be an important programme. We, therefore, recommend that in no case should such lands be distributed among local landless and agricultural labourers. Often times, islands of cultivation occur amidst large tracts of wasteland. While planning reclamation for contiguous wastelands such sown areas are to be included. We recommend that necessary legislation should be enacted to enable consolidation of wastelands inclusive of the scattered patches of sown area and allot the displaced landowners alternative lands of equivalent value elsewhere in the vicinity of the affected villages.

17.3.11 Extensive areas affected by shifting cultivation, (Jhumming or podu or kumri) occur as unproductive land in the tribal hills of North Eastern India, Orissa Madhya Pradesh, Andhra Pradesh etc. In the worst affected areas of shifting cultivation, the loss of soil and vegetation present a desolate picture of barren hills. In consequence, the concerned tribal people only eke out a precarious living. Land affected by shifting cultivation assumes high priority in the schedule of land reclamation for increasing productivity. In this direction, integrated land development programmes using alternate or composite land use on watershed basis offers promise in uplifting the tribal economy in such areas. Detailed information on shifting cultivation and

the methods of treating this problem have been discussed in Chapter 18 on Soil and Moisture Conservation and Chapter 42 on Production and Social Forestry.

4 PROPOSAL FOR THE FUTURE

17.4.1 With the pressure of population there is always an attempt to reclaim and utilise wastelands of various kinds for cultivation. Past experience shows that sometimes the method of reclamation and the use to which the land is put lead to greater deterioration of the soil leading to a situation of no return. For each type of wasteland there has to be a considered programme of reclamation which will gradually build up the soil and ultimately bring the land back to continuous productive use. The process may be long requiring lot of effort and also capital investment. There is no easy way to reclaim wastelands for productive use; but considering the value of a productive hectare of land today quite substantial capital investment will be justified in reclamation of wastelands. During the last decade, various pilot schemes for reclamation of different types of wastelands that have been discussed in Section 3 have been tried out in different parts of the country. There are also traditional methods of reclamation which have been used for decades like the coastal mangrove area reclamation in the Balasore district of Orissa. An analysis of the traditional and the modern scientific approach to the problems will have to be made to evolve for each area a suitable package of practices.

17.4.2 There has to be a systematic survey of the different categories of wastelands in the different states. Though from time to time a census of such wastelands has been attempted, the magnitude of the problem has still got to be established in many of the States. Further, wasteland reclamation is going on continuously because of the pressure on land and the situation cannot be static at any time. If reclamation is not done scientifically wastelands may deteriorate further leading to loss of productive area. There is, therefore, a need for rapid survey of the position and systematic action to bring the wastelands into effective use in the best scientific manner possible. Each category of wasteland has its peculiar problems and special approach to its reclamation. An attempt has been made in the following paragraphs to suggest some further approaches to reclaim and utilise the different categories of wastelands described in Section 2.

Land Infested with Shrubs and Bushes

17.4.3 These areas are best suited for fodder and fuel wood deve-

lopment. In our Interim Report on Social Forestry we have already drawn attention to the need for bringing substantial areas out of this type of wastelands into fuel wood and small timber plantation for meeting the needs of the expanding rural population and semi-urban areas. The type of growth to be encouraged will depend upon the experts, judgment as to the species that will be best suited to the agro-climatic conditions of the area. There is a lot of information available with the silviculturists and the forest research institutes about suitability of the fuel wood and timber species for such areas. A continuous updating of knowledge regarding the most remunerative and rapid growing species is required of the silviculturists in order to meet different ecogeophysical situations. The other important use to which these lands can be put is to develop them into fodder reserves and rangelands for livestock raising. Under the community development programmes controlled grazing and cheap methods of fencing the blocks for rejuvenation of fodder have been tried out in various parts of the country from the results of which knowledge about some of the best methods are available. In our Interim Report on Desert Development, we have drawn attention to the need for rangeland development and fodder reserves in desert areas. The methods of doing so have also been indicated. It will be necessary to systematically develop these wastelands into suitable fodder reserves and link up with intensive programmes of cattle and sheep development.

Ravines

17.4.4 The immediate necessity to stop the spread of ravines to the marginal cultivated lands has been emphasised in Section 2. This requires some amount of land levelling on the plateaus and soil conservation and drainage works on the top fringes of the ravines. The estimate of the Working Group for this has been reproduced at items (1) and (2) in Appendix 17.3. At the 1972 costs it would require an investment of Rs. 69.5 crores. The draft Fifth Plan has made in the Central sector a provision of Rs. 3 crores for this purpose. Considering that the ravine areas can be brought back into irrigated agriculture by suitable investment as has been explained by the Working Group and considering the scarcity of good cultivable areas in these regions, there is a need for rapid reclamation of the ravine areas in the four States, viz. Gujarat, Rajasthan, Madhya Pradesh and Uttar Pradesh, in order to provide timber fodder and cultivable land.

Sand Dunes

17.4.5 Sand Dunes are prevalent in the hot desert areas of the

Indian arid zones which occupy about 3.2 lakh sq. km. and lie in the States of Rajasthan, Gujarat and Haryana. Our Interim Report on Desert Development has dealt, in detail, with not only reclamation of these lands in these desert areas but also their general economic rehabilitation. There is no easy method of reclamation of sand dunes and of preventing the creeping of sand dunes into neighbouring cultivable areas. The main recommendations made by us are :

(i) With the water available during the first five years or so of the construction of channels in the command area of Rajasthan Canal the sand dunes in the command area and along the canals should be brought under grass and tree cover to stabilise them.

(ii) Outside the command of Rajasthan Canal, surveys should be undertaken to determine the extent of works required for the stabilisation of shifting sand dunes which pose a threat to towns and railways and works taken up.

(iii) In the command areas of Rajasthan Canal, stabilisation of shifting sand dunes in compact blocks of 20 hectares and above should be taken up by the Government after enlisting the support of the village Panchayats which should be entrusted with the task of protection. The income from the sale of grass and trees including lops should be shared equally between the Government and the Panchayats.

(iv) As a support of afforestation, grassland improvement and sand dune stabilisation programmes, the Forest Department should establish, on a priority basis, the base for research on different aspects of forestry in desert areas supplementing the efforts by the Central Arid Zone Research Institute in this direction. The Institute should also give adequate importance to research in forestry along with other agricultural problems.

(v) Sand dune stabilisation programme should be planned for 20,000 hectares in 15 years, the first preference being given to the smaller dunes (less than 1.5 metre high) which are the most active.

Stabilisation of sand dunes will be a part of desert development and will have to be done from the canal areas outwards. Wind breaks and shelter belts have also been recommended to prevent further encroachment by sand dunes.

Waterlogged Areas

17.4.6 Waterlogged lands contiguous to the sea coast have brackish water. They were always reclaimed either for crop cultivation or fish

cultivation. The utilisation of mangrove forests in the Balasore coast and of the Bheri system of fish culture in West Bengal are examples. Recently, however, both world experience and research done at the Central Inland Fisheries Research Institute (CIFRI) at the Kakadweep Centre in Sunderbans have shown that the most profitable use of these brackish areas is to develop controlled tank fishery development for prawn and certain highly priced brackish water fish like Bhekti, Milk Fish, etc. This new scientific way gives the hope that large areas along the coast can be employed for controlled brackish water fisheries. The method and approach have been dealt with in detail in the Chapter 37 on Inland Fisheries and Aquaculture. Similarly, the fresh water-logged areas can be brought back into either good cultivation or fresh water pisciculture. The pilot scheme of the United Nations Development Programme (UNDP) in the Chambal area has established proper methods of bringing such areas into cultivation by suitable land shaping and key drainages. In certain parts of West Bengal, such marshy areas are being transformed into effective fresh water fisheries where the composite fish culture development by the Central Inland Fisheries Institute have been effectively used. Both the Chambal experiment and the methods evolved by the CIFRI show that capital invested either in reclaiming the area into cultivable lands or fishery tanks are both commercially economical.

17.4.7 Afforestation of these areas is of considerable economic importance. As regards trees, the choice of species is influenced, apart from the waterlogged condition, by the nature of soil and climate. In general the growing of fruit trees should not be attempted in water-logged areas, except that of guava which may grow under condition of high water table. Poplar, certain varieties of eucalyptus, specially *Eucalyptus robusta, Lagerstrosmia flosreginae Dalbergia latifolia, Barringtonia acutangula, Bischofia javanica* grow well in swampy areas. But all these trees require drainage prior to planting. *Casuarina equisetifolia* has grown well on waterlogged sandy soils and on coastal flats. In areas liable to inundation *Zizyphus jujuba, Butea monosperma* and *Acacia nototica* can grow freely. Planting trees on ridges or mounds promotes their growth. To make such plantations profitable, they have to be on extensive areas. Waterlogged lands can also be utilised for growing certain grasses and sedges. Amongst the grasses for fodder which would grow on such lands may be mentioned Para, Dallis, Napier and Guinea. For making mats Korai and Murta can be grown while *Sachharum munja* can be grown and used for thatching[1].

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1 Planning Commission (1963) Study of Wastelands including Saline Alkali and Waterlogged Lands and their Reclamation Measures, pp. 135-141.

Saline and Alkali Soils

17.4.8 On the basis of researches done at the Central Soil Salinity Research Institute, (CSSRI), Karnal, a large scale reclamation project of saline sodic soil in the country has since been proposed by the Department of Agriculture, Ministry of Agriculture and Irrigation in the Fifth Plan proposals. However, the field problems of using brackish water in several areas for reclamation and the design specification for costly drainage system still pose problems for cultivators' acceptance. The cost factor involved in these reclamation measures for saline and sodic soils needs further investigation to bring it within the economic reach of the cultivators. Also alternative land utilisation methods by raising suitable grasses and economic forest species may have to be explored for reclamation and better utilisation of such land with less cost. In view of this, intensification of research at CSSRI, Karnal is recommended. In order to transfer the available technology operational research projects are recommended to be taken up on contiguous problem areas of about 1,000—2,000 hectares with a view to evaluating the economic feasibility of the practices under alternative land use. It is further recommended that research studies should be made for exploring the possibility of composite fish culture in dug out ponds in the salt affected land which generally has low permeability.

Riverine Beds

17.4.9 The problems of 'Diara' land need to be investigated as a multidisciplinary research programme and suitable practices evolved for the management of sandy areas, flooded and waterlogged land and salty land, apart from evolving a suitable crop and forage production technology.

Chos and Khads

17.4.10 The reclamation of 'cho' devastated area has been taken up in Punjab and the flow of a group of 'Chos' upto the outfall has been successfully canalised as evidenced by the works done at Nasrula 'cho', Mallanwali 'cho' and Mechangarwal 'cho'. The Soil Conservation Research Centre, Dehra Dun has also undertaken research studies in this area. Suitable vegetative-cum-structural measures have been evolved as spurs, bed stabilizers, etc. The more important result obtained at Dehra Dun is the economic utilisation of the bouldery and abandoned 'cho' beds by means of fuel fodder plantations, using such species as *Dichanthium annulatum, Chrysopogon fulvus, Dalbergia sissoo, Acacia Catechu.* Efforts are being continued here to utilise

such lands for plantation of *bhabhar grass* (*Eulaliopsis binata*) and orchard trees of guava and budded *ber* etc. In view of the extensive nature of wastelands, it is necessary to intensify research for developing technology for successful establishment of permanent cover of economic species of fuel, fodder, inferior fruit trees and fast growing industrial species. Pilot research studies in large contiguous blocks should be undertaken to standardise the management methods and to evolve working plans for maximising production and economic returns. There is also a felt need to improve further the design and specification of costly structures in canalising the 'chos'. Intensive investigations on design specification, material research etc. should be taken up to evolve cheaper measures for large scale canalisation of 'cho'. Irrigation research institutes and river research institutes located in the 'cho' affected areas and concerned agricultural universities may initiate coordinated programme of field investigations in this direction.

Coastal Sandy Lands

17.4.11 Orissa has done a lot of work in the reclamation of the sandy coastal areas by providing a windbreak of *Casuarina equisetifolia* along the coastline on the sandy tracts having a second line of windbreak and soil conservation through plantations of cashewnuts. In the third line, coconut plantations have been started. These plantations have been very effective as all the three trees are economically most useful. Large scale reclamation of the coastal tracts along these lines is suggested.

Stony and Gravelly Lands

17.4.12 Sizeable rocky and stony area lie as wasteland. According to the land use capability classification, they are categorised as fit for no vegetation. Such wastelands can only be developed for recreation purposes and for developing them as Nature reserves. No systematic research has yet been conducted on this aspect. As most of the rocky and stony areas lie under the jurisdiction of the Forest Departments, it is important that the Forest Research Institute and the State Forest Departments initiate research to develop these wastelands as recreation spots and Nature reserves.

Lateritic Soils

17.4.13 Extensive areas of shallow lateritic soils lie as wasteland under sparse but uneconomic vegetation. Research is, therefore, to

be taken up to identify suitable species and develop technology for increasing production from such lands. Scope for utilising these lands which have relatively thick soil cover may be explored through research for fruit trees like cashew, wood apple, *aonla* jack fruit and forest species like 'mahua', eucalyptus, etc. Shallow soils are suitable for development of grasslands using fertilisers. The Indian Grassland and Fodder Research Institute, Jhansi should undertake suitable investigations for development of grassland on these soils. In collaboration with the State Governments pilot research projects for grassland development should be undertaken to transfer the available technology to the field.

High Altitude Steep Slopes and Meadows

17.4.14 Mention has been made of the research success achieved by the high altitude agronomy at Leh farm. In view of this it is recommended that research work leading to increased agricultural production and development of alpine pastures and meadows in high altitude locations should be intensified. The Indian Grassland and Fodder Research Institute, Jhansi should take up this research work. Further, the Himalayan watersheds are very important for the most fertile Indo-Gangetic plains of the country. They feed the river system and enrich the underground water resources. In view of this that the ICAR should intensify watershed research for soil conservation and proper land utilisation by suitably introducing crops, grassland, orchards and medicinal plants. Forest Research Organisations should intensify research to evolve comparatively fast growing forest trees suitable for this region. Multiple land use with a view to rationalising land use practices for watershed protection, reduction of silt discharges and saving the life of costly reservoirs, should also be initiated.

Land Affected by Shifting Cultivation

17.4.15 Shifting cultivation has been practised from time immemorial in the tribal areas of Assam, Manipur, Tripura, Orissa, Madhya Pradesh and Andhra Pradesh. As a traditional form of cultivation in a heavy rainfall area where weed growth is rapid, such a system of cultivation may have had its use when population pressure was low and the *jhum* area could be left fallow for a number of years. With population pressure developing, the *jhum* rotation is becoming shorter and shorter and has led to rapid soil erosion. As a result in many parts of Orissa and Andhra Pradesh the bed rock has been exposed. Danger of landslides occur in the high rainfall areas of North East India. It is, therefore, necessary to develop these areas with a production

programme which whilst preserving the soil will gradually improve the economic conditions of the people of the area. Several programmes of reclamation are under way in these zones. Though the population utilising these lands is large for a *podu* or *jhum* rotation, it is yet not too large for a programme of controlled reclamation and settlement under regular agriculture, animal husbandry or forestry. The strategy outlined below has been developed after careful consideration of the *pros* and *cons* of the matter:

(i) reclaiming land where necessary and providing minor irrigation where possible so as to encourage settled cultivation in villages and on terraced slopes on the lines adopted by Savaras of Orissa and Angamis in Nagaland, assuring at the same time inputs, fair price shops communication and marketing facilities;

(ii) identifying areas suitable for plantation crops such as tea, coffee, rubber, which would give subsidiary occupation for a family on the basis of one hectare of plantation;

(iii) developing grass reserves to support a subsidiary programme of animal husbandry; and

(iv) developing suitable areas for agri-silvicultural operations, commercial forest plantations, which would give full occupation to a large number of village population.

Because of the diversity of conditions prevailing in areas which are subject to *jhum* cultivation in the country, one or the other of the above strategies would apply. The correct decision has to be taken after careful study of the situation and on the basis of available experiences. It should be admitted that the practice cannot be entirely eliminated but by gradual adoption of the measures suggested above the evils of *jhum* cultivation may be minimised. The various States in the north-eastern region and the States of Orissa and Andhra Pradesh have accepted these programmes which now form a part of the Fifth Five Year Plan. An intensification of the programme can be taken up after the present programmes have been established as demonstrations of both suitable alternative employment and economic viability (*vide* Chapter 59 on Special Area Development Programmes).

17.4.16 The magnitude of the problem of land reclamation has been spelt out in earlier Sections. About 58 million hectares or more are lying unutilised in the country and await reclamation for better and productive land use. The approach to the reclamation of different tracts of wastelands is different; so will be the financial implications. Irrigation and measures to control floods, adoption of better water management practices, introduction of contour bunding, terracing, sand dune stabilisation measures, etc. are some of the programmes which are required to be undertaken. But at the same time, it has to be

recognised that there is a close interdependence among the various programmes to reclaim the wastelands. Ordinarily, irrigation facilities have to precede reclamation measures. Therefore, a well coordinated programme has to be worked out. These elements make the task of precise financial estimates somewhat difficult.

17.4.17 From our Interim Report on Desert Development some idea can be had about the requirements of outlays for the development of desert areas. We have estimated that a total amount of Rs. 932 crores, excluding the expenditure till the end of Fourth Plan on the construction of Rajasthan Canal, Pong Dam and new lift canals, may be required over a period of 15 years for the development of desert area. Of this, programmes estimated to cost about Rs. 91 crores will have a direct bearing on land reclamation. Once the programmes recommended by us are undertaken, these would immensely help in the reclamation of desert areas in Rajasthan, Haryana and Gujarat. The Working Group of the Ministry of Home Affairs, Government of India, on Ravine Reclamation Programme for dacoit infested areas of Uttar Pradesh, Madhya Pradesh and Rajasthan has recommended a 7 years programme for the reclamation of 1.1 lakh hectares of ravine areas and for ancillary ravine control covering 2.2 lakh hectares in each of the three States. The outlay recommended is of the order of Rs. 94.5 crores for each State. Out of this, it has been recommended that the institutional finances should account for Rs. 55 crores. It is also suggested that a part of the cost of bunding of table land may be realised from individual beneficiaries.

17.4.18 In a paper entitled "A Charter for the Land"[1] an attempt has been made to estimate the outlay involved, for the country as a whole, in the development of land affected by various erosion hazards and maladies. According to the author of this paper, a total outlay of about Rs. 23,000 crores will be required over a period of 30 years or more to implement various reclamation programmes. The details of the outlay are given in Appendix 17.4. The paper has also indicated that since 60 per cent of this outlay represents investment of a productive nature and, can, therefore, be financed from institutional sources, less than 40 per cent of this outlay will have to be met by the Government directly. These estimates require review in the light of present circumstances. The above examples, however, give a broad picture of the large investment required to tackle the programme of reclamation. Although the total outlay required is very high, the problem can be solved by staggering the programme over a long period and by tapping institutional sources, realising a part of the cost from the individual beneficiaries and by inducing them to undertake certain programmes themselves.

1 1972, Vohra B. B., Additional Secretary, Ministry of Agriculture and Irrigation (Department of Agriculture).

17.4.19 It will be noticed that the following land reclamation programmes are substantially based on irrigation extension and irrigation control :

(i) ravines;
(ii) sand dunes;
(iii) waterlogged areas;
(iv) land with saline and alkaline soil;
(v) river beds; and
(vi) chos and khadins.

These will comprise the bulk of the wasteland available for good reclamation. It is also these lands where reclamation costs may be high. The phasing of this development has to be related to the phasing of the irrigation development in the country. In Chapter 15 on Irrigation, we have indicated that the full irrigation potential will be reached over a period of 50 years. As reclamation will have to be done after the irrigation system materialises, it will be reasonable to phase the reclamation programme over a period exceeding 50 years. Though direct investment by the State during the Fifth Plan period appears to be small, the various programmes that are being undertaken will be pilot programme for large scale extension of land reclamation in future. The main thrust of the programmes will be felt from the Sixth Plan onwards. The land reclamation programmes like ravine reclamation, etc. which require irrigation support, are on present indication commercially viable programmes. After reclamation the land will bear much higher value than the cost of reclamation. It should, therefore, be seen that reclamation is substantially done through institutional investments availed of by persons to whom the lands to be reclaimed is allotted. It may also be possible for a land reclamation organisation in a State to take up advance reclamation of an area and then selling the land at a fair price to settlers. We would recommend that the land reclamation programme should be attempted on either of these basis so that direct investment by the State is limited and substantial investment comes from the farmers themselves through borrowings from institutions for long term agricultural credit. If the farmer is enabled to reclaim and develop a part of his land, it will generate sufficient return to enable him to undertake reclamation of the remaining parts of his holding in stages. We would also like to stress that in undertaking investments for reclamation social costs and benefits should be kept in view and not merely economic costs and benefits. Only then can the large scale programme we have envisaged be implemented within a reasonable frame of time.

17.4.20 According to the principles of growth with social justice, marginal farmers and landless labourers will have to be brought within

a reasonable production programme by inducting them on the lands which have been reclaimed. The State has been following a system of subsidising the capital costs for small and marginal farmers so that they can earn straightaway an additional income from the programmes instead of having to wait for a decade or so before real profits accrue. At the same time, where irrigated agriculture is possible subsidies can be substantially reduced ; so also in the case of composite fish culture and brackish water fish culture. During each Plan a suitable programme of reclamation with allocations to the marginal farmers and labourers will have to be worked out by each State and necessary provisions made in the programme for such help as is thought desirable at that time for encouraging the poorer sections of the community.

17.4.21 Land reclamation should form a part of area development. The planning, evaluation and coordination cell at the district level will have to do the base work in identifying the lands and formulating programmes. With the help of the State planning unit, the Central planning division will then have to formulate the overall national programme keeping in view the relative needs of the States for land, the needs of growth with social justice in the backward regions and depending on the funds that are available both for direct investment by the State and through the institutional sector. For each plan period an operational Plan will have to be drawn up on this basis. It has to be noted that quite a large area of wastelands which are suitable for reclamation are already held by tenants in various States. Once the method of development is known and the necessary inputs are made available along with institutional credit, it is to be expected that the owners of these lands will themselves seek to improve their economy by taking up reclamation themselves instead of waiting for area programmes. Particularly in the field of reclamation of saline and alkaline lands and waterlogged areas and also some marginal ravine areas, a lot of these individual enterprises can be expected. This will in our view add to the pace of the reclamation programme very substantially. Being parts of area development programmes, the organisation for carrying through the reclamation programmes will have to be the various area development authorities which have been recommended by us (of Chapter 59 on Special Area Development Programmes). No separate organisation for planning and execution of land reclamation programmes seems necessary. Land reclamation will be one part of the overall area development.

17.4.22 Land reclamation will require the help of tractors and machinery, and exploitation of the reclaimed areas will require substantial services and input supplies. All these will have to be arranged as a part of their general work by the area development authorities through existing organisations. In the various States land develop-

ment corporations, agroindustries corporations and departmental custom services have been organised and will be organised. In addition custom services are being developed through unemployed engineers and rural entrepreneurs. The area development authorities will have to take advantage of these custom service organisations developing in the rural areas. There is no need either for a centralised programme for land development or a centralised organisation for carrying out the programme.

17.4.23 Land reclamation problems will vary from area to area depending on the agroclimatic conditions. The agricultural universities will have to provide the scientific guidance and investigational support in all problems that may arise locally as the programmes develop. These problems will be extremely localised and are best tackled by the extension organisation suitably helped by the scientific staff of agricultural universities. Problems of research will have to be automatically dealt with by the university under the normal frame that we have recommended for formulating research programmes annually and carrying them out in Chapter 52 on Research.

5 SUMMARY OF RECOMMENDATIONS

17.5.1 The important recommendations made in the chapter are as follows :

1. In the command areas of major irrigation projects, where problems of waterlogging and salinity exist, apart from the provision of drainage, water courses and field channels, an economy in the use of water and exploitation of ground water to lower the water table should be insisted.

(Paragraph 17.2.7)

2. The areas liable to flooding and waterlogging in the country should be identified. They should be brought under suitable crops avoiding flood periods.

(Paragraph 17.2.9)

3. In areas where reclamation projects are being launched, detailed mapping indicating classification of the salt-affected soils together with their characteristics should be initiated.

(Paragraph 17.2.14)

4. Reclamation of saline and saline-alkali lands should be attempted on a large scale in order to prevent infestation of soils from neighbouring areas. Physico-chemical characteristics of the soils should be periodically observed to enable modifications, if any, of reclamation methods.

(Paragraph 17.2.16)

5. A suitable subsidy may be given to small and marginal farmers owning alkali affected lands for purchase of gypsum for reclamation.

(Paragraph 17.2.16)

6. Pilot operational research projects on watershed basis covering 2,000—3,000 hectares of land should be taken up to assess the economic feasibility of developing rangelands. Standard soil survey should be carried out to delineate different land capability classes suitable either for cultivated crops or grasses or forest plantations.

(Paragraph 17.2.18)

7. There is an urgent need to carry out soil surveys in the ravine lands for the purpose of differentiation of the soils. For whatever areas aerial photographs are available they should be interpreted to find out the physical features of the land, characterising ravine systems. For those areas for which aerial photographs do not exist, urgent steps should be taken to have them.

(Paragraph 17.2.23)

8. Property boundaries and field boundaries should not be allowed to interfere in the way of scientific planning of ravine land reclamation. The land consolidation and settlement operations should be simultaneously undertaken. Areas considered suitable for horticultural crops should similarly be planned on contours and redistributed to facilitate speedy development. Areas recommended for forestry should also be subjected to run-off management.

(Paragraph 17.2.28)

9. The economic benefits should not form the sole basis in the reclamation of ravine lands. Poverty and the objective of curbing the activities of antisocial elements should receive due consideration. Ravine reclamation as such should receive national priority and investment should not be denied on account of unfavourable benefit-cost ratio.

(Paragraph 17.2.29)

10. In multiple channel rivers occupying vast areas under their beds, the subsidiary channels should be diverted, wherever feasible, into the main river and the land under the bed reclaimed. The canalisation of such rivers on which dams have been constructed may be effected downstream of the dam so as to bring large areas of riverine waterlands for profitable land use.

(Paragraph 17.2.30)

11. Wherever feasible, the technique and experience already available in grouping 'chos' for their canalisation and the reclamation of 'cho' devasted land for better land use should be adopted extensively.

(Paragraph 17.2.31)

12. About half the coastal areas, which are partly saline, would be amenable to reclamation through plantations. Using the available technology, coastal plantations of *Casuarina,* eucalyptus, coconut, cashew, *chikku* etc. should be taken up extensively for profitable land use.

(Paragraph 17.2.34)

13. Stony and gravelly lands lying extensively as wasteland should be closed to grazing for a few years to establish good vegetative cover before controlled grazing is permitted.

(Paragraph 17.2.35)

14. Intensive research and development programmes should be taken up for evolving rational land utilisation and obtaining economic production from shallow laterite soils through establishment of orchards of certain fruit trees, plantations of quick growing fuel species of pastures and grassland.

(Paragraph 17.2.36)

15. Urgent measures should be taken to put steep slopes in the Himalayas watershed under permanent vegetation and grasses to prevent soil erosion and heavy silt discharges from endangering life of reservoirs.

(Paragraph 17.2.37)

16. The causes of land lying waste should be examined by the concerned State departments in order to chalk out a strategy for its reclamation. The schemes for development and utilisation of the wastelands should be formulated in coordination with the Forest and Revenue Departments and democratic institutions like the Zila Parishad.

(Paragraph 17.3.1)

17. The categorisation of all wasteland in the country in blocks less than 100 hectares should be completed on priority basis as a Centrally sponsored scheme. Aerial photographs and remote sensing techniques for survey of locating and planning the use of wastelands should be adopted. The interpretation of the aerial photographs and that of soil survey reports of wastelands should be done on uniform basis so as to have uniform results. During the soil survey of wastelands, data on water table should be collected and compiled since these data would help in better and more economic utilisation of land.

(Paragraph 17.3.4)

18. Extensive areas are lying unutilised or underutilised along the railway lines, national highways, rivers, canals, etc. Such land needs to be reclaimed and utilised according to the land use capability.

For effective implementation of the programme, it would be necessary to have a coordination committee consisting of representatives of the concerned Ministries/departments at the Central level.

(Paragraph 17.3.5)

19. While distributing wastelands to the landless agricultural labour, ex-servicemen, etc., provision for necessary inputs to undertake cultivation and scientific reclamation, viz., agricultural implements, improved seeds, pesticides, irrigation and credit facilities should be made by the Government.

(Paragraph 17.3.6)

20. Afforestation of wastelands with fast growing species could be helpful in converting large areas of such lands for other useful purposes. In the earlier stages of development afforestation of such wastelands should, therefore, be considered from the larger perspective of utilisation for protective purposes rather than for purely financial returns.

(Paragraph 17.3.9)

21. There is an urgent need for attaining self-sufficiency in fodder, fuel, small timber and soft wood for pulp. In this context, country's wasteland or unutilised land offers great scope. Reclamation of wasteland should be planned to meet the above demands of national importance.

(Paragraph 17.3.10)

22. To enable the local livestock industry to develop faster than hitherto in hilly and desert areas, development of pastures should be an important programme. In no case should such lands be distributed among local landless and agricultural labourers.

(Paragraph 17.3.10)

23. Necessary legislation should be enacted to enable consolidation of wastelands inclusive of the scattered patches of sown area and allot the displaced land owners alternative lands of equivalent value elsewhere in the vicinity of affected villages.

(Paragraph 17.3.10)

24. Efforts should be intensified to bring substantial portions of wastelands under fuel and small timber plantations for meeting the needs of expanding rural and semi-urban population.

(Paragraph 17.4.3)

25. A continuous updating of knowledge regarding the most remunerative and fast growing species is required in order to suit different eco-geophysical situations.

(Paragraph 17.4.3)

26. The available wastelands should be reclaimed and converted into suitable fodder reserves to support the intensive programmes

of cattle and sheep development.

(Paragraph 17.4.3)

27. On the basis of available technology and past experience in the fields, there is a great need for rapid reclamation of the ravine areas of Gujarat, Rajasthan, Madhya Pradesh and Uttar Pradesh in order to provide timber, fodder and cultivable land.

(Paragraph 17.4.4)

28. The recommendations made on sand dunes reclamation and stabilisation in our Interim Report on Desert Development are reiterated.

(Paragraph 17.4.5)

29. Researches on alternative and less expensive land utilisation methods by raising suitable grasses and economic forest species may have to be explored for reclamation and better utilization of saline and sodic soils. In view of this, there is a need for intensification of research at the Central Soil Salinity Research Institute, Karnal. Operational pilot research projects should be taken up on contiguous problem areas of about 1,000-2,000 hectares with a view to evaluating the economic feasibility of the practices under alternative land use like agriculture. Studies should be made for exploring the possibility of composite fish culture in dug out ponds in the salt affected land which generally has low permeability.

(Paragraphs 17.4.7 and 17.4.8)

30. The problems of riverine wasteland known as 'Diara' lands need to be investigated and suitable practices evolved for the management of sandy areas, flooded and waterlogged land and salty land, apart from evolving a suitable crop and forage production technology.

(Paragraph 17.4.9)

31. In view of the extensive nature of wastelands, it is necessary to intensify research for developing technology for successful establishment of permanent cover of economic species of fuel, fodder, inferior fruit trees and fast growing industrial species. Pilot research studies in large contiguous blocks should be undertaken to standardise the management methods and to evolve working plans for maximising production and economic returns. There is also a felt need to improve further the design and specifications of costly structures in canalising the 'chos'. Irrigation research institutes and river research institutes located in the 'cho' affected areas and concerned agricultural universities may initiate coordinated programme of field investigations in this direction.

(Paragraph 17.4.10)

32. Rocky, stony and hilly areas with skeletal soil are not considered suitable for agriculture and forestry but can be developed

for recreation purposes and Nature reserves. The Forest Research Institute and State Forest Departments should initiate research in this direction.

(Paragraph 17.4.12)

33. Research work should be taken up to identify proper grass species suitable for wastelands occupied by shallow lateritic soils and develop technology for increased production from such lands. The Indian Grassland and Fodder Research Institute, Jhansi should undertake suitable investigations for development of grassland on these soils. In collaboration with the State Governments pilot research projects for grassland development should be undertaken to transfer the available technology to the field.

(Paragraph 17.4.13)

34. Research work leading to increased agricultural production and for development of alpine pastures and meadows at high altitude location should be intensified at the Indian Grassland and Fodder Research Institute, Jhansi.

(Paragraph 17.4.14)

35. The Indian Council of Agricultural Research should initiate watershed research for soil conservation and proper land utilisation with a view to rationalising land use practices for watershed protection and reduction of silt discharges thereby saving the life of costly reservoirs.

(Paragraph 17.4.14)

36. The rehabilitation of tribal people who practise *jhum* cultivation in one form or the other may be attempted in one or more of the following ways :

(i) reclaiming land and providing irrigation, where necessary, and other inputs and facilities so as to encourage settled cultivation ;

(ii) identifying areas suitable for plantation crops which would give subsidiary occupation ;

(iii) developing grass reserves to support a subsidiary programme of animal husbandry ; and

(iv) developing areas for agri-silvicultural operations and commercial forest plantation which would give full occupation.

(Paragraph 17.4.15)

37. Land reclamation should substantially be done through institutional investments availed of by the allottees. Alternatively, it may also be possible for a land reclamation organisation in a State taking up advance reclamation of an annual area and then selling the land at a fair price to the settlers. The land reclamation programme should be attempted on either of these basis so that direct investment by the State

is limited and substantial investment comes from the farmers themselves through borrowings from institutions for long term agricultural credit.

(Paragraph 17.4.19)

38. The land reclamation should form part of area development and would not require any separate organisation. The Central planning division will have to formulate the overall national programme, with the help of State planning units, keeping in view the relative needs in the States for land, of growth with social justice and depending on funds available from the State investment and institutional borrowing.

(Paragraph 17.4.21)

APPENDIX 17.1

(Paragraphs 17.2.1 and 17.2.3)

Extent of Waterlogged Area as Estimated by Various Agencies

(lakh hectares)

	National commission for irrigation@	Sehgal and Rattan Singh[1] (1972)	Information from other sources	Summary and estimate of available data
Punjab	10.90	14.27	..	10.90
Haryana	6.20			6.20
Uttar Pradesh	8.10	6.90	..	8.10
Bihar	NR	NR	1.17	1.17
Rajasthan	3.48	NR	..	3.48
Gujarat	NR	4.84	0.60*[2]	4.84
Madhya Pradesh	0.57	NR	0.33[3]	0.57
Karnataha	0.07	NR	0.10[4]	0.10
Andhra Pradesh	NR	0.04	3.39**	3.39
Maharashtra	0.28	1.11	..	1.11
West Bengal	18.50	3.09	..	18.50
Orissa	..	..	0.60	0.60
Tamil Nadu	..	..	0.18[5]	0.18
Kerala	..	..	0.61[6]	0.61
Delhi	..	0.01	..	0.01
Jammu & Kashmir	..	0.10	..	0.10
				59.86

@ Waterlogging is not a serious problem in the States of Assam, Orissa, Andhra Pradesh, Tamil Nadu, Kerala and Gujarat. Though replies are not received from the States of Jammu & Kashmir and Nagaland, it is not a serious problem in those States except for some areas in Kashmir Valley.

NR — Not reported/indicated.

* In Shetrunj area alone.

** The area includes those under Nagarjuna Sagar Project Command area and in the deltas of the Krishna and the Godavari.

1 Sehgal, S. R. and Rattan Singh, 1972. Review of bibliography on waterlogging and drainage. International Hydrologic Decade Newsletter, India, No. 15 pp. 13—40.

2 Raj, P. A. and Bapat, M. V., 1972. Symposium on Waterlogging, Causes and Measures for its prevention CBIP Vol. II, Publication No. 118 : pp. 79—88.

3 Pandya, G. S., 1972. Symposium on Waterlogging, Causes and Measures for its prevention CBIP Vol. II, Publication No. 118 : pp. 53—62.

4 Achar, H. P. and Bhadrapur T. G., 1972. Symposium on Waterlogging, Causes and Measures for its prevention CBIP Vol. II, Publication No. 118 : pp. 124—128.

5 Nagarajan, D. K., 1972. Symposium on Waterlogging, Causes and Measures for its prevention CBIP Vol. II, Publication No. 118 : pp. 63—71.

6 Iyer, V. L. and Narayanan, K. S., 1972. Symposium on Waterlogging, Causes and Measures for its prevention CBIP Vol. II, Publication No. 118 : pp. 100—108.

APPENDIX 17.2

(Paragraph 17.2.11)

Distribution of Saline, Saline-Alkali and Alkali Lands in Different States[1]

State/Union Territory	Total area affected ('000 hectares)	Soil group in affected lands	Districts affected by	
			Saline conditions	Saline-alkali and alkali conditions
1	2	3	4	5
Andhra Pradesh	240	deltaic alluvium	East Godavari, West Godavari	
		medium and deep black soil	Krishna, Guntur	Nizamabad, Karimnagar, Mahbubnagar, Kurnool, Anantapur, Guntur, Cuddapah
Bihar	4	alluvial soil developed on Indo-gangetic alluvium	Muzaffarpur, Shahabad	
Gujarat	1214	coastal saline	Kutch, Jamnagar	
		desert and grey brown soil	Banaskantha, Mehsana, Ahmedabad, Surendranagar	
		medium and deep black soil		Broach, Surat, Bulsar,- Bhavnagar, Kaira.
Haryana	526	alluvial soil developed on Indo-gangetic alluvium	Hissar, Bhiwani	Karnal, Kurukshetra, Rohtak, Sonepat, Jind, Gurgaon
Karnataka	404	medium and deep black soil	Belgaum, Raichur, Bellary	Bijapur, Dharwar, Chitaldrug, Gulbarga.
Kerala	16	acid sulphate soil of the deltaic region	Alleppey, Kottayam, Ernakulam	

1 Compiled from the Working Paper prepared for the Commission by Dr. D. R. Bhumbla, Director, Central Soil Salinity Research Institute, Karnal.

APPENDIX 17.2 (Concld.)

1	2	3	4	5
Madhya Pradesh	242	medium and deep black soil		East Nimar, West Nimar, Dhar, Bhind, Morena, Gwalior, Shivpuri
Maharashtra	534	Do.		Jalgaon, Aurangabad, Parbhani, Nasik, Ahmednagar, Sholapur, Poona, Satara
Orissa	404	deltaic alluvium	Cuttack, Balasore, Puri	
Punjab . .	688	alluvial soil developed on Indo-gangetic alluvium	Ferozepur, Faridkot, Bhatinda	Gurdaspur, Amritsar, Kapurthala, Patiala, Sangrur
Rajasthan	728	Do.	Alwar, Jaipur, Tonk, Bharatpur, Sawai Madhopur	
		desert and grey brown soil	Ganganagar, Bikaner, Nagaur, Churu, Jaisalmer, Barmer, Jodhpur, jalore, Ajmer, Pali, Sirohi, Sikar.	
		mixed red and black soil		Kota, Bundi, Bhilwara, Chittorgarh, Banswara.
Tamil Nadu	4	deltaic alluvium	Thanjavur	
Uttar Pradesh	1295	alluvial soil developed on Indo-gangetic alluvium	Mathura, Agra	Aligarh, Etah, Etawah, Mainpuri, Hardoi, Kanpur, Unnao, Lucknow, Fatehpur, Rae-Bareli, Sultanpur, Azamgarh, Ghazipur Pratapgarh, Meerut.
West Bengal	850	deltaic alluvium		24 Parganas, Midnapur
Delhi	16	alluvial soil developed on Indo-gangetic alluvium		Delhi.

4M of A&I/76—16.

(Paragraph 17.4.4)

APPENDIX 17.3

Perspective Plan for Ravine Reclamation—Estimates of Targets and Costs

Area (lakh hectares)
Cost (Rupees crores)

Item	Uttar Pradesh		Madhya Pradesh		Rajasthan		Total for three States	
	target	cost	target	cost	target	cost	target	cost
1	2	3	4	5	6	7	8	9
Ravine investigation planning and designs	15.00	7.50	15.00	7.50	7.00	3.50	37.00	18.50
Ravine control measures	7.00	21.00	7.00	21.00	3.00	9.00	17.00	51.00
Reclamation for agriculture	4.10	143.50	2.00	70.00	1.00	35.00	7.10	248.50
Reclamation for horticulture	1.37	13.70	2.15	21.50	0.72	7.20	4.24	42.40
Reclamation by biological treatment	1.37	10.96	2.15	7.20	0.72	5.76	4.24	23.92
Total ravine area programme	6.84	196.66	6.30	127.20	2.24	60.46	15.58	384.32
Total watershed area programme	13.84	..	13.30	..	5.44	..	32.58	..
Irrigation of ravine land reclaimed for agriculture and horticulture	5.47	164.10	4.15	124.50	1.72	51.60	11.34	340.20
Total for ravine reclamation and irrigation	6.84	360.76	6.30	251.70	2.44	112.06	15.58	724.52
Capital equipment and machinery, number of bulldozers ancillary equipment and workshop*	10.25	30.75	500 (numbers)	15.00	250	7.50	1775	53.25
Building and access roads (6 per cent of works)	..	22.06	..	15.70	..	6.72	..	44.48

*The requirement takes into account both the factors of extra machines for rooting (33.3 per cent) and the factor of manual labour reclamation (25 per cent).

APPENDIX 17.3 (Concld.)

1	2	3	4	5	6	7	8	9
Staff and office contingencies and overheads etc. (25 per cent of works)	..	90.19	..	65.43	..	28.01	..	183.63
TOTAL	6.84	503.76	6.30	347.83	2.44	154.29	15.58	1,005.88
Additions due to increase in ravinous areas during the assumed 27 years period from 1972-73 to 1998-99 (half of average increase rate of 0.5 per cent)	0.46	34.00	0.45	23.48	0.16	10.41	1.07	67.89
TOTAL	7.30	537.76	6.75	371.31	2.60	164.70	16.65	1,073.77
Electric power supply for irrigation and rural electrification	23.52	70.43	19.39	58.27	7.40	22.23	50.31	150.93
GRAND TOTAL	7.30	608.19	6.75	429.58	2.60	186.93	16.65	1,224.70

Source : 1972. *Report of the Working Group on Ravine Reclamation Programme for Dacoit Infested Areas of Uttar Pradesh, Madhya Pradesh and Rajasthan*, Table No. 10, pp. 45-46, New Delhi, Ministry of Home Affairs, Government of India.

APPENDIX 17.4

(Paragraph 17.4.18)

Financial Implications of Land Reclamation

(Rs. crores)

	Total outlay	Government outlay	Institutional outlay
Education and public relations	10	10	Nil
Soil survey	100	100	Nil
Control of water erosion	5,400	2,000	3,400
Control of wind erosion	3,000	2,000	1,000
Control of sea erosion	100	100	Nil
Engineering works for flood control	2,000	2,000	Nil
Major drainage and control of waterlogging	8,000	2,000	6,000
Optimum use of irrigated areas	4,400	Nil	4,400
Soil testing and maintenance of fertility levels	20	20	Nil
Administrative expenses including prevention of diversion of good lands	20	20	Nil
	23,050	8,250	14,800

Source : Vohra B. B., 1972, A Charter for the Land, Ministry of Agriculture (Department of Agriculture), pp. 22-23.

18

SOIL AND MOISTURE CONSERVATION

1 INTRODUCTION

18.1.1 Soil and water are two very important natural resources not only for agriculture but for the existence of life *per se*. Conservation of soil and water assumes a special significance in a watershed because of the role played by them in the development of regional economy. Soil and water sustain natural vegetation, which in turn helps to conserve them. This mutual interaction gives rise to an ecological balance in nature. Wanton denudation of vegetative cover has taken place owing to pressure on land for the production of food and fodder, Nature being unable to regenerate as fast as the process of destruction. Loss of soil and water has been the most immediate consequence. This loss is irreparable on sloping lands. It is in this context that soil conservation has been conceived as a process of prevention of soil loss by adoption of anti-erosion measures. The concept of soil conservation has, however, broadened with time to meet the requirement of efficient and productive use of land. The emphasis, therefore, requires to be laid on soil and crop management on watershed basis.

18.1.2 India has widely varying climate, soil, land use pattern and topographical conditions. Rising from the Himalayas, the Western Ghats and the plateau territory of Malwas a number of major rivers drain the land. A large number of rivers, streams and their tributaries provide natural drainage ; the water flow varies with the location and nature of the terrain, and the intensity and duration of precipitation. The whole country may thus be considered to consist of different watersheds of diverse drainage systems. The problems connected with the movement of the large volumes of water vary from watershed to watershed depending upon soil, rainfall, management practices and socio-economic conditions of the people inhabiting them.

18.1.3 The development of water resources is intimately linked with watershed management. Hence, it becomes imperative to know the watershed in its entirety for a reasonably accurate estimate of water

yield. Proper management of watershed requires that the water yield is maintained unimpaired. Another aspect of watershed management is concerned with optimum land use and sustained productivity. Conservation measures and soil and crop management practices should be such that loss of soil and soil moisture is minimised. Conservation of soil and moisture in a watershed has, therefore, two aspects, namely, their conservation in the catchments of river valley projects and in the cultivated areas. The conservation in the catchment areas is aimed at serving the dual purpose of saving the soil by keeping the soil under optimum vegetative cover and of prolonging life of storage reservoirs by reducing siltation. The conservation problems of cultivated lands are specifically concerned with the different types of conservation measures and their efficacy, agronomic practices, economics and other aspects. Whereas in the catchment areas soil conservation measures almost automatically conserve soil moisture, this is not so in lands cultivated under rainfed conditions. In the latter, special efforts have to be made to conserve soil moisture. These aspects of soil and moisture conservation together with the need for collecting basic and reliable information on soil and water, and the need for research work on conservation and siltation under conditions prevailing in the country have been highlighted in this chapter.

2 PROBLEM AND ITS MAGNITUDE

Land Use Pattern

18.2.1 The land use pattern of a country broadly underscores the problems of soil and hence of moisture conservation. The present land use pattern in the country is the result of interaction of various demands on land mainly for production of food, fibre, fodder, oilseed and trees (forest). The Land Utilization Statistics published by the Directorate of Economic and Statistics (DES), Union Ministry of Agriculture and Irrigation, provide an idea of the pattern of classification of land area in the country (*vide* Appendix 18.1). It would be seen from the figure given in Appendix 18.2 that forests cover 66 Mha only. But even within this forest area there is a substantial extent which has been depleted because of over-exploitation and uncontrolled grazing in the past for meeting the local demands of the population. These areas are either eroded or liable to erosion resulting in loss of productive soils.

18.2.2 Hilly and mountainous areas are subject to land slides and slips besides surface wash and gullying. The incidence of landslides is

found to be more where grazing intensity is high. Landslides are a major cause of watershed degradation in some river catchments particularly those in the Himalayan region. In the hilly areas in Assam, Manipur, Nagaland, Tripura, Meghalaya, Mizoram and Arunachal Pradesh where the tribal population predominates, an age-old method of crop husbandry known as shifting cultivation or *jhumming* is practised. The areas thus affected by shifting cultivation has been estimated at 2.7 Mha (see Table 18.1). A similar type of cultivation known as *podu* prevails in the hilly forests of Orissa and Andhra Pradesh over an area of about 0.3 million hectares. The pressure of population on the land has progressively hastened the process of shifting cultivation, so that a cycle of operations of 20 to 30 years in the past is completed at present in 4 to 6 years. As a result, shifting cultivation has resulted in severe damage to the soil resources of these regions. A critical evaluation of the problem has been made in our Chapter 42 on production and Social Forestry.

TABLE 18.1

Area affected by Shifting Cultivation[1]

(thousand hectares)

State	Areas
Assam	498.3
Meghalaya	416.0
Manipur	100.0
Tripura	220.8
Nagaland	608.0
Mizoram	604.0
Arunachal Pradesh	248.6
TOTAL AREA	2,695.7

About 29 Mha shown as "barren and unculturable land" (Appendix 18.1) constitute probably the most severely eroded areas. The magnitudes of 'culturable lands' and 'fallow land other than current fallows' indicate neglected land management. These areas are liable to erosion. The areas categorised as 'permanent pastures' and 'other grazing lands' covering 13 Mha perhaps represent, fallaciously though, some of the worst eroded areas. Whether it is the pasture lands of the desert or of the high hills, they are characterised by

1 1975. *Land Statistics of India*, New Delhi. Soil Conservation Division, Ministry of Agriculture & Irrigation, Government of India.

unchecked misuse. The grazing is by and large unrestricted and widely practised in forest areas, the livestock feeding on undergrowth and tress-passing into the young regenerated areas. This type of indiscriminate grazing has caused great damage to forestry. Grazing lands in general are rendered almost unproductive leading gradually to growth in patches of inferior and coarse grasses. Development of grasslands and rigorous restrictions on grazing are the only means of improving such lands.

Wastelands and Ravines

18.2.3 The wastelands in general include gullies and ravines. The problem of soil deterioration caused by gullies exists in all categories of land. Scenes of degradation and damage are noticeable on the banks of rivers and streams of northern and western India, namely, the Yamuna, the Chambal, the Mahi, the Sabarmati and their tributaries. Gullies and ravines are estimated to have damaged 3.67 Mha in Uttar Pradesh, Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Punjab, Bihar, Tamil Nadu and West Bengal, (*see* Table 17.4 in Chapter 17 on Land Reclamation and Development). The problem has assumed urgency because the ravines are fast spreading into cultivated lands. It has been assessed that in Madhya Pradesh alone about 700 hectares of good tableland are degenerating into ravines every year. Fast flowing rivers and streams erode their banks and engulf the productive cultivated lands and forest areas around. Torrent erosion is prevalent in the hills and valleys having steep slopes. No estimate of this type of erosion is available.

Cultivated Lands

18.2.4 It will be seen from Table 18.2 that out of 140 Mha of net area sown, 31 Mha are irrigated, leaving 109 Mha in which cultivation is done under rainfed conditions. A gross area of 37 Mha is under rice of which 15 Mha are irrigated and the remaining 22 Mha are under rainfed rice. Irrigated areas are considered to be properly levelled and shaped so that they are subject to minimal erosion. The area under rainfed rice which is levelled, shaped and adequately bunded for holding water is also well protected from the eroding influence of rainfall. Area under rainfed crops other than rice works out to be 87 Mha. Up to the end of the Fourth Plan about 15 Mha of cultivated land had been treated with soil conservation measures—9.4 Mha up to the end of the Third Plan and an estimated area of about 6 Mha during the Fourth Plan. There will be some rainfed area where cultivators themselves have taken suitable conservation measures at their own initiative.

About 70 Mha will still be liable to erosion. More and more marginal lands are being brought under cultivation without taking suitable conservation measures thereby aggravating erosion problems in such lands.

TABLE 18.2

Estimates of Area under Rainfed Crops, 1970-71[1]

(thousand hectares)

State	Net area sown	Net area irrigated	Net area under rain-fed crops
Andhra Pradesh	11,735	3,313	8,422
Assam	2,235	572	1,663
Bihar	8,454	2,160	6,294
Gujarat	9,220	1,209	8,011
Haryana	3,565	1,532	2,033
Himachal Pradesh	546	89	457
Jammu & Kashmir	706	264	442
Karnataka	10,248	1,137	9,111
Kerala	2,172	431	1,741
Madhya Pradesh	18,352	1,480	16,872
Maharashtra	17,668	1,344	16,324
Manipur	140	65	75
Meghalaya	162	37	125
Nagaland	60	12	48
Orissa	6,119	1,149	4,970
Punjab	4,053	2,888	1,165
Rajasthan	15,179	2,132	13,047
Tamil Nadu	6,169	2,592	3,577
Tripura	240	22	218
Uttar Pradesh	17,305	7,219	10,086
West Bengal	5,633	1,489	4,144
Union Territories	437	108	329
All India	1,40,398	31,244	1,09,154

Wind Erosion

18.2.5 In addition to erosion by water, there are large areas where erosion is caused by high velocity wind. Wind erosion is common in

1 Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India.

arid and semiarid desert regions which occupy about 32 Mha. Considerable wind erosion taking place along the sea coasts in parts of West Bengal, Orissa, Tamil Nadu, Karnataka and Maharashtra has been partially checked in large parts by creating forest belts of *Casuarina* trees during the last fifty years. The problems of erosion in desert areas especially those of sand dunes, have been dealt with in our Interim Report on Desert Development. The observations and recommendations made therein are reiterated in this Chapter. It has been roughly estimated, but not based on any systematic survey, that an area of about 150 Mha suffers from serious water and wind erosion, sedimentation damage, and other types of deterioration, and is in urgent need of scientific conservation and management. Out of this an area of 69 Mha is estimated to be in a critical state of deterioration. In the remaining areas, erosion is slight or none at all.

Specific Problem of Catchment Areas

18.2.6 The magnitude and urgency of soil conservation in catchment areas began to be realised towards the end of the Second Five Year Plan when it was noticed that in some of the reservoirs the rate of siltation was faster than expected and that their capacities were fast diminishing. In a seminar held at Hirakud (Orissa) in 1957 it was suggested that two to five per cent of the cost of river valley projects should be set apart for taking up soil conservation measures in the catchment areas of the various river valley projects. At the meeting of the Agriculture Ministers held in 1961 at Bhubaneshwar, a recommendation in the following terms was accepted :

> "In order to avoid national waste it is essential that before any new project is taken up in future, careful estimates are made of the soil conservation measures necessary to prolong its life. Estimates of financial provisions for these measures should form an essential part of the project itself. Further, adequate soil conservation programmes should be initiated and a firm assurance about financial provision given before any new project is taken up for construction".

In 1965, the then Central Soil Conservation Board made a further recommendation that "No fresh dam construction should be taken up until the Soil Conservation Board is satisfied that adequate protection of the catchment areas will be given by the time the construction of the dam is completed". In spite of the magnitude of the task and the above recommendations the amount spent for catchment treatment from the First Plan to date is around Rs. 50 crores. The Irrigation Commission (1972) mentioned the need of Rs. 800 crores for

watershed management. The singular nature of the conservation problem makes it necessary to formulate a long term action programme.

18.2.7 During the period of fourth five year plans and a number of annual plans over 11 thousand sq. km. of catchment area could be treated against an estimated 1.5 million sq. km. covering 59 major projects. Even against a total catchment area of 0.78 million sq. km. for 21 major projects under the centrally sponsored programmes, the achievement is no more than 1.4 per cent. From a study of aerial photographs covering about 0.2 million sq. km. in the catchment of these 21 river valley projects, it is estimated that the areas requiring soil conservation measures in the different catchments vary from 11 to 39 per cent. It is generally assumed that in order to substantially overcome the siltation problem, it would be adequate to treat 10 to 15 per cent of the high silt producing areas in the catchment, which are considered critical. Even on this basis the overall achievement is no more than 10 per cent. A rough estimate shows that completion of the work would require 5 to 6 plan periods and cost about Rs. 1,500 crores. The progress of work done is so very meagre that it is premature to assess the impact of the conservation works executed so far on reduction of siltation. In all the projects whether completed or under execution, the hazard of reservoir sedimentation is equally serious. A number of Himalayan rivers cause flood havoc every year and their watersheds deserve special programmes of soil conservation and protection. A comparison of the time available for watershed treatment on the basis of existing siltation rates shown in Appendix 18.3 with the number of years that will be needed to complete the watershed treatment measures shows that siltation hazards will overtake conservation efforts in a number of projects. The list (Appendix 18.3) further shows in a progressive manner the projects which do not afford the time for watershed treatment, even if loss of 50 per cent live storage is reckoned as the economic limit. It is, therefore, considered of utmost importance to plan a firm strategy for completing the conservation work quickly, preferably within the next five years.

Basic Consideration of Land Use

18.2.8 The permanent solution to the problem of sediment formation is the on-site control of erosion. Undisturbed watersheds completely covered with vegetation yield sediment almost equivalent to the rate of geological erosion. Examples of a few reservoirs in the country, which have sustained for long periods—even up to an estimated 500 years—are known in Central India, the catchments of which are very stable, being covered with extensive well-protected reserved forests. A perusal of the existing land use conditions of eleven major

projects in India reveals that not more than 20 to 25 per cent of the watershed areas are covered with forests. These lands too are under heavy pressure of grazing and other biotic interference. As much as 50 per cent of watershed areas are occupied by crop lands of which not more than 10 per cent are irrigated. This broad analysis indicates the inefficiency of the present land use pattern in the watersheds to sustain a desirable sedimentation rate. It is, therefore, imperative that any watershed management programme should indicate, as far as possible, quantitative estimates of benefits.

Reservoir Surveys

18.2.9 The hazard of reservoir sedimentation has been briefly mentioned in paragraph 18.2.6. The problem is so serious that a closure scrutiny is required to obtain some quantitative information. Reservoir surveys in the country date back to 1870 and were carried out at intervals of 5, 10 and 20 years. The available data show that the reservoirs surveyed have very small capacity compared to the respective watersheds. Moreover, catchments of these reservoirs are hilly and wooded with very little production of silt. The data so available indicate a maximum annual silt production of 3.5—4.5 hectare metres per 100 sq. km. Similar data are available in some of the developed countries. The results of calculation based on the above data are different from the actual as has been subsequently realised. When the first indication of the high rate of sedimentation in reservoirs was available in a few cases, the Central Board of Irrigation and Power initiated systematic sedimentation surveys in streams and reservoirs. Such surveys have shown that the actual incidence of sedimentation per 100 sq. km. of catchment area varies from 6 hectare metres in Bhakra Nangal to 16.4 hectare metres in Mayurakshi that is, about 2 to 5 times the rate assumed in the projects. The data for 23 major reservoirs are presented in Appendix 18.3. The tabulated data are based on capacity survey and inflow-outflow studies conducted by the Central Board of Irrigation and Power in collaboration with various engineering research institutes. In 9 of these reservoirs the sedimentation has been assessed by capacity surveys and in 12 reservoirs sedimentation data have been obtained by the inflow-outflow method. No survey has so far been made in the remaining two. The capacity survey method is direct and dependable, whereas the inflow-outflow method is approximate. It has been observed that the rate of siltation in almost all cases, except the Machkund reservoir, has been several times more than that assumed in the project reports. In the case of Machkund reservoir the observed siltation is less than that assumed at the time of project planning. Considerable soil conservation measures have been taken in

the watershed of the Machkund reservoir but it has not yet been exactly assessed to what extent they are responsible for the reduction of silt flow into the reservoir. In other catchments such as the Damodar Valley, soil conservation measures are going on, and though the observed siltation has not come down to the assumed level, there is perceptible reduction in sediment inflow. The observations highlight the necessity of expediting soil conservation measures in catchments of the existing reservoirs. It is obvious that by adopting proper watershed management the silt inflow will be reduced. Prevention of siltation no doubt saves the reservoir but it is the prevention of soil loss that is of utmost significance, because soil once lost is never to be recovered. Also, it takes more than one thousand years for an inch of top soil to form. Watershed management should, therefore, essentially centre round soil conservation.

Encroachment on Live Storage

18.2.10 Recent surveys of a number of reservoirs (*vide* Table 18.3) have revealed that sediments have already encroached upon the live storage space. This finding gives reasons for alarm and has thrown up certain problems relating to the functioning of reservoirs and some important aspects of their designing.

TABLE 18.3

Percentage Loss of Storage Capacity in the Different Allocated Zones and of the Total Capacity upto 1974[1]

Name of reservoir	Loss in dead storage	Loss in live storage	Loss in total capacity	Remarks
Bhakra	16.0	2.5	5.6	capacity survey conducted every year
Maithon	26.0	12.0	10.7	projected over 1971 figures
Panchet	35.2	17.8	9.2	capacity survey completed in 1974
Mayurakshi	21.2	7.7	9.2	projected over 1970 figures
Tungabhadra	..	..	9.4	capacity survey completed in 1972
Nizamsagar	100.0	60.4	62.0	projected over 1967 figures
Lower Bhawani	100.0	3.8	4.0	projected over 1965 figures
Matatilla	15.0	8.5	10.5	projected over 1969 figures
Sivajisagar	..	..	0.8	details not available

1 Data obtained from the Central Water Commission (CWC) and Ministry of Agriculture and Irrigation; they are based on capacity surveys of the reservoirs.

The life of reservoir starts getting affected even before the dead storage meant for trapping reservoir silt is filled up. The total utilisable storage provided for in a project gets reduced by siltation. There is a reduction of live storage right from the year of impounding as the velocity of water gets reduced as soon as the flow reaches the reservoir. The Irrigation Commission identified the location of sediment deposit in reservoirs and stated as follows :

> "Some of the sediments in a river may be deposited upstream of a dam, some may pass through it without being deposited, but much of it is deposited in the dead storage but some of it may also find its way into that portion of the dam which is reserved for live storage. The problem of encroachment on the live storage capacity is more acute in reservoirs like Hirakud where the waterspread area behind the dam is very large and silt is deposited in shallows on the edge of the lake."[1]

18.2.11. Earlier reports by Central Water Commission (CWC) showed a capacity loss of about 50 per cent in the case of Nizamsagar reservoir and a reduction of nearly 5,000 hectares in irrigable area. According to the 1974 data (Table 18.3) obtained from the same source, the loss has further aggravated and is estimated at 62 per cent. Consequently, a further decrease in irrigation command must have taken place. It is feared that such condition might occur in other reservoirs. The decrease in irrigated area in the command of a project after its initial full development can be due to one or more of the following situations:

(a) lower water availability in the particular year or years than that planned;
(b) increase in water demand due to changes in agricultural practices; and
(c) loss of capacity of the reservoir due to siltation.

Of these, the last situation is a real cause for alarm. Hence, whenever decrease in irrigation in command area is noticed, the above situations should be examined. In case reduction in irrigation is found to be due to loss of reservoir storage capacity caused by excessive siltation, proper watershed management and remedial measures for soil erosion should be stepped up immediately.

3 BENEFITS OF CONSERVATION MEASURES

18.3.1 On the basis of land use pattern and reservoir survey

1 Report of the Irrigation Commission, 1972, Vol. 1 paragraph 14.10, Ministry of Irrigation & Power, Government of India.

pointed attention has been drawn in the foregoing pages to the quantitative aspects of problems of soil and moisture conservation in the catchment area. There are two distinct but closely interrelated facets, namely, problems of sloping lands and those of the plains. Moreover, depending on the rainfall, soil properties, topography, cropping patterns and socioeconomic conditions, the treatments would vary from one catchment to another. The benefits accruing from such treatments would likewise vary. Problems of command areas which would be under irrigated cultivation and measures of conservation there have been adequately dealt with in Chapter 16 on Command Area Development.

Protection Benefits

18.3.2 The benefits of watershed management are of two kinds, namely, protection and production benefits. They are, however, interrelated. The protection benefits are indirect, a quantitative measure of which is the reduction of sediment inflow into the reservoir. As a consequence, the life of the reservoir is prolonged, streams flow stabilised and water regime of the area improved. The production benefits are direct and depend on the valuable surface soil containing humus saved, thereby enhancing production of field crops, timber, grasses, etc. Soil conservation measures in the catchments of various river valley projects are in progress for more than a decade. State Governments were required to evaluate the effectiveness of these measures qualitatively as well as quantitatively. Experience shows that systematic studies in this respect are lacking and the States generally evaluate achievements in terms of physical and financial targets. Some have tried to evaluate the effects of soil conservation measures in terms of reduction of siltation. Several interesting evidences have been collected in course of execution of schemes of soil conservation in the catchments of river valley projects during the Third and Fourth Plans. Wherever land treatment measures have been properly implemented by judicious provision of vegetative cover, very often combined with small structural reinforcement, sedimentation rates have been reduced. Some of these measurements have been made by constructing weirs and installation of self-recording discharge gauges, accompanied by collection and analysis of sediment samples. In the Damodar Valley Catchment, measurements have been accurately made in 16 subwatersheds by conducting successive surveys of deposited sediments in the detention structures. The results of these observations are given in Table 18.4.

TABLE 18.4

Changes in Sediment Outflow Rate following Conservation Measures in Damodar Valley Catchment areas[1]

Name of the watershed-nullah	Watershed area in hectares	Sediment outflow rate prior to soil conservation measures ha m /sq km	Sediment outflow rate after soil conservation measures ha m/sq km
Sandur-pandri	56.25	0.40	0.023
Dandai	256.58	0.31	0.025
Amnari	126.27	0.20	0.015
Kolghati	119.79	0.46	0.028
Bonga	295.84	0.15	0.009
Kasura	110.89	0.18	0.018
Mandai	45.33	0.25	0.021
Tilaiya (1)	186.97	0.30	0.023
Tilaiya (2)	77.70	0.25	0.022
Badhiajuar	108.46	0.36	0.006
Bijladih	170.38	0.20	0.013
Konrahar	207.21	0.30	0.020
Naguan	862.42	0.21	0.020
Sakha barashi	473.09	0.15	0.015
Mayapur	160.26	0.16	0.019
Piprahi	167.14	0.26	0.023

1 Personal Communication.

The data presented in the above table clearly demonstrate the efficacy of control measures. A few other outstanding cases may be mentioned in which reduction of sediment flow has been effected by land treatment and other engineering measures. In Machkund catchment, for example, the assumed annual silt rate was 3.8 hectare metre/100 sq km of the catchment. Extensive soil conservation measures including control of shifting cultivation, terracing a large proportion of cultivated lands, introducing plantation crops etc., have brought down the sediment yield rate to 2.36 hectare metres/100 sq km. As a result of the diversified land use programme, the tribal people are

cultivating the land almost every year instead of every two to three years. A significant change in cropping pattern, namely, from lesser millets to rice has been brought about in many of the lands treated with conservation measures. A reduction has been effected in sediment inflow rate in two major reservoirs of the Damodar Valley Catchment, namely, Maithon and Panchet. The siltation rate of Maithon was reduced from 15.2 hectare metre/100 sq km to 9.6 hectare metres/100 sq km in course of 10 years. Evaluation report of the Kundha Project (Tamil Nadu) for 1971-72 provides similar information on the reduction of rates of siltation following conservation measures.

18.3.3 Even though in small subwatersheds it has been possible to drastically reduce the sediment outflow (Table 18.4), it may not be easy to achieve a sedimentation rate of 3.5 hectare metre per 100 sq km in most of the watersheds, as was assumed by the designers while planning the projects. This may be ascribed to the large size of the watershed, inefficient land use pattern and indifferent management. If the whole of the watershed can be treated as in the case of the small subwatersheds referred to in Table 18.4 or, if a substantial portion, say two-thirds, of the catchment area is terraced and covered with permanent vegetation like forests, it may be possible to achieve the assumed sedimentation rate.

Production Benefits

18.3.4 Production benefits following conventional soil conservation measures have been reported from several States. In the semiarid alluvial plains of Uttar Pradesh about 35, 60 and 98 per cent increases in yield of *Kharif* and *rabi* crops have respectively been obtained by bunding alone, levelling alone and combined bunding and levelling. In Maharashtra, contour bunding has not only increased the yield of crops in dryfarming areas but also raised the water level in the wells. In Ramganga river valley project random sampling indicated over 50 per cent increase in food production in terraced lands over the unterraced ones. In the case of Kundha catchment (Tamil Nadu) 15—65 per cent increases in the yield of potato have been obtained by terracing. The efficacy of bunding has been questioned because of heavy cost involved and little return in most of the marginal and wastelands. But often the reasons are lack of maintenance and unsuitability of such lands for intensified cropping.

18.3.5 Results of treatment of nonagricultural lands have been quite encouraging. In Karnataka, Madhya Pradesh, Rajasthan, Uttar Pradesh, Maharashtra and the Damodar Valley catchment areas the yields of grasses have increased from 13—30 q/ha to 16—125 q/ha by simple closure and optimum management. Similar encouraging

results have been obtained in Raigarh and Ujjain districts of Madhya Pradesh where increased production of grass has been reported. Large paddocks were created in the Chambal catchment of Rajasthan, which saved the migratory livestock during dry months. In places where benefits were appreciable the cost could be realised quickly and the maintenance was good, but wherever the benefits were marginal the paddocks fell into disrepair. The main problem of the treated non-agricultural lands, which have so far been confined to government lands, is to protect them from indiscriminate grazing and fire and depredation by poor catchment dwellers. For lack of adequate protection, a considerable proportion of the afforested areas are, in fact, getting denuded.

18.3.6 From the above illustrations it is evident that expenditure incurred for watershed management is justified on the basis of production as well as protection benefits, some of which are direct and immediate and others long range and indirect. The observations of the Irrigation Commission in this context are reproduced below:[1]

> "Soil conservation measures in the catchment area of a storage irrigation project have great significance for the life of the storage reservoir. These measures generally comprise bunding, terracing, afforestation and pasture development. A good watershed development plan will serve more than one purpose. It would lead to higher agricultural production in the catchment area through increased yields, improve forest and grasslands and, therefore, income from such land, exercise moderating influence on medium and small floods, improve low flows in the streams, and reduce silt yield from the catchment. These benefits are difficult to quantify and evaluate with precision".

4 PAST EFFORTS AND PRESENT STATUS

Pre-Independence Period

18.4.1 The degradation of land caused by ravines along the banks of the Yamuna, the Chambal etc. had drawn governmental attention as early as 1884. Ravines and wastelands in Uttar Pradesh were at that time taken over from zamindars for the purpose of control of erosion and creation of fodder and fuel reserves. Protection of land from the menace of *cho* (mountain torrents) also received early attention and one of the first enactments for prevention of soil

1 1972. Report of the Irrigation Commission, Vol. I : 255. New Delhi, Ministry of Irrigation and Power, Government of India.

deterioration was passed in the Punjab in 1900 as Land Preservation Act. It provided for such measures as *wat bandi* (ridge formation), contour trenching, gully plugging, terracing, tree planting, preservation of forests, etc. for preventing the havoc caused by *cho*. A survey in an area in Chota Nagpur region of Bihar showed that during a period of about 45 years since the beginning of this century, approximately 17 per cent of the surveyed area was lost to cultivation through gully erosion.[1]

18.4.2 The Royal Commission on Agriculture (1928) took cognisance of instances of soil deterioration which arose from the erosion of surface soil. They recommended rapid expansion of afforestation of ravine lands in United Province (now Uttar Pradesh) as a means of preventing soil erosion and to investigate the actual extent of soil erosion in the Bombay Presidency. They also suggested studies on the feasibility of combining the methods adopted in United Province and Bombay for prevention of soil erosion with those in Western Bengal and the submontane districts of the Punjab.

18.4.3 Soil conservation research in the country was initiated during 1933—35 when the Indian (then Imperial) Council of Agricultural Research (ICAR) decided to establish five regional centres for research on dryfarming at Sholapur (Maharashtra), Bijapur, Raichur and Bellary (Karnataka), and Rohtak (Haryana). The work carried out at these stations, upto 1954 has been reviewed[2]. Soil and moisture conservation assumes great importance in rainfed agriculture which constitutes the bulk of agricultural practice in the country. Holding rain water by construction of bunds, green manuring, wider spacing of crops, cultivation of khariff crops on shallow soils and fallowing in deep soils were important measures recommended by research stations. Strip cropping with alternating legumes and cereal crops was recommended in undulating lands having problems of soil erosion. Soil conservation work was taken up on a large scale by the then Bombay State on the basis of a Statute in the Land Improvement Schemes Act, 1942. Till 1950, Maharashtra State did pioneering study on a big scale not only on problems of soil erosion and methods of conservation, but also on extension of conservation measures to cultivated lands. The assessment of benefits of soil conservation measures has revealed that (a) contour bunding resulted in augmentation of subsoil water supply in wells; and (b) contour bunding increased crop production upto 35 per cent, which was further increased by 25 per cent by adopting dryfarming practices in bunded areas. More fallow lands were thus brought under cultivation.

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1 1958. Farm Planning and Management, New Delhi, Ministry of Agriculture & Irrigation, Government of India.

2 Kanitkar, N. V., Sirur, S. S. and Gokhale, D. N. 1960. *Dry Farming in India*, New Delhi, Indian Council of Agricultural Research.

Post-Independence Period

18.4.4 Soil and moisture conservation received considerable attention during the First Five Year Plan (1951—56). It was recognised that the ultimate aim of soil conservation was not only to control erosion but also to maintain the productivity of soil at a high level. In view of the seriousness of erosion problems in some soil and agro-climatic regions stress was, however, largely on anti-erosion measures. Emphasis was laid on the enactment of soil conservation legislation in the States and the setting up of appropriate administrative machinery at the Central and State levels. With a view to developing a research base for soil conservation, the First Plan provided for the establishment of a Soil Conservation Branch at the Forest Research Institute, Dehra Dun, a Desert Research Station at Jodhpur and six research and demonstration centres in other parts of the country, namely, Ootacumund (Tamil Nadu), Bellary (Karnataka), Kota (Rajasthan), Vasad (Gujarat), Agra (Uttar Pradesh) and Chandigarh. These centres broadly represented a large part of the soil and agro-climatic regions of the country, especially the main problem areas. Details of research done in these centres have been given in Section 7 of the chapter. Soil conservation work on cultivated land was initiated in Andhra Pradesh, Gujarat, Kerala, Tamil Nadu, Maharashtra and Karnataka but bulk of achievement in the First Plan was in the erstwhile States of Bombay and Madras. The Second Plan envisaged, in addition to the work of the First Plan, soil conservation in river valley project areas, dryfarming demonstrations and survey of ravine lands. Additional schemes for soil conservation on cultivated lands, dryfarming and reclamation of saline and alkaline lands were drawn up for the Third Plan. Reclamation of culturable waste lands and settlement of landless agricultural labourers formed on important component of the Third Plan schemes. The scheme for surveying the ravine affected areas drawn up for the Second Plan could be initiated in the Third Plan. In the Fourth Plan the Coordinated Research Project of the ICAR on dryfarming started to function in 24 centres spread over the different agro-climatic regions of the country.

Soil Conservation Programmes

18.4.5 Soil conservation in the first three plans in cultivated lands was covered by diverse schemes. One group of schemes related to contour bunding, terracing and other soil conservation measures. The other group related to watershed treatment for minimisation of siltation in reservoirs of the major river valley projects and the develop-

ment of cultivated areas in the watersheds. The third group of schemes comprised construction of field embankments, pilot schemes on ten acre plots in dryfarming on bunded and unbunded lands. Plantation of trees or cash crops on hill slopes and on the banks of rivers and soil conservation in desert areas were other important items of soil conservation work taken up during the plan periods. The overall progress made in soil and moisture conservation and reclamation of problem lands during the above plan periods is adequately expressed by the following factual information[1]. Soil conservation work carried out on cultivated lands throughout the country upto the beginning of the Fourth Five Year Plan was estimated at 9.4 Mha. Culturable wastelands were estimated to have been reclaimed to the extent of 0.2 Mha upto the beginning of the Fourth Plan. In the scheme for surveying ravine affected areas, an area of 1.6 lakh hectares was covered by ground surveys and another 4 lakh hectares by aerial photographs. Up to the end of 1968-69, 32,000 hectares of ravine affected areas were reclaimed for agriculture purposes and 56,000 hectares were afforested.

18.4.6 Even though soil conservation programmes were initiated on a countrywide scale towards the end of the First Five Year Plan, practically very little progress was made in the catchments of river valley projects. In the Second Plan such conservation work formed part of the developmental programmes of the States. As the progress was not considered satisfactory, a special provision of Rs. 11.21 crores was made for a centrally sponsored programme during the Third Plan; eight additional projects were included under this programme. At the end of 1973-74 an area of about 11,000 sq. km was treated with soil conservation measures at a total expenditure of about Rs. 48 crores (vide Table 18.5). The percentages of lands treated under forests, agriculture and pastures during the period 1961-62 to 1973-74 were respectively 36.48, 51.41 and 12.11. The Fourth Plan witnessed a definite change in the strategy of soil conservation work. While the protection of watersheds of important river valley projects received continued emphasis, other areas of development like soil and water management practices in irrigation commands, reclamation of ravine lands and development of dryfarming practices were included in the programme.

1 1973. Report of the Working Group on Land and Water Development, Fifth Five Year Plan (1974—79), New Delhi, Ministry of Agriculture and Irrigation, Government of India.

TABLE 18.5

Planwise Expenditure on Soil Conservation and Area Covered[1]

Period	Expenditure (Rs. in crores)	Area covered (thousand hectares)
first plan	0.36	13.76
second plan	2.07	85.37
third plan	11.21	316.15
annual plans (1966—69)	9.45	235.55
fourth plan	23.96	455.33
total:	47.05	1106.16

Present Status

18.4.7 From what has been described in Section 2 and stated above, it is now realised that soil conservation is much more than erosion control. It has to be a programme which should provide for the conservation and all round development of the two basic natural resources, namely, soil and water, for sustained production at a high level. In the Fifth Plan, soil and moisture conservation is proposed to be undertaken in an area of 9 Mha at an estimated expenditure of Rs. 298 crores[2]. An allocation of Rs. 44 crores has been made for the programme of catchment treatment during the Fifth Five Year Plan with three more projects to be covered, viz., Pagladia (Assam), Rengoli-Mandira (Orissa, Bihar and Madhya Pradesh) and Daman Ganga (Gujarat).

State Replies to Questionnaire

18.4.8 Replies to the questionnaire issued to the States regarding soil and moisture conservation works were received from 14 States. The questionnaire included among others the following queries:

(i) present status of soil and land use survey;

(ii) present position regarding demarcation of the State into different agro-climatic zones;

(iii) nature and extent of soil conservation work carried out;

1 Information received from the Central Water Commission, Ministry of Agriculture and Irrigation, Government of India.

2 1974. Draft Fifth Five Year Plan 1974—79. Government of India, Planning Commission. Appendices XII & XIV.

(iv) soil conservation measures, types, specifications, techniques, etc. as applicable to the requirements of different agro-climatic zones; and

(v) benefits of soil conservation measures, etc.

From the compilation of the replies of the States (Appendix 18.4) it would appear that very few States take up soil survey and land capability interpretation as a pre-requisite to soil and moisture conservation measures. Delineation of agro-climatic zones in most States has been done either on the basis of rainfall or topography or soil. Cropping pattern or land use has rarely been taken into consideration. The States have generally laid great stress on bunding as being the main item of soil conservation work. In regard to benefits from soil conservation measures the majority of the States have reported increased yields of crops and raised water table in the wells. The assessment of benefits has not been based on statistically laid out experiments and hence questionable. Land levelling and shaping work has mostly been done in the command areas of the irrigation projects but very little work on land shaping in dry areas has been taken up.

Collection of Silt Data of Rivers and Streams

18.4.9 The work of collecting silt and discharge data of the main rivers and their tributaries is the responsibility of the engineering section of the projects but that of rivers/streams having catchment area up to 625 sq km sediment gauging is being done by the soil conservation organisations in the States. The following agencies are participating in silt data collection :

(i) Ganga Water Resources Organisation, Ministry of Agriculture & Irrigation;

(ii) Central Water Commission (CWC); Ministry of Agriculture and Irrigation;

(iii) Irrigation and Flood Control Departments of the States; and

(iv) State Soil Conservation Organisations in charge of river valley projects.

The Central Soil Mechanics Research Station (CSMRS) of the CWC receives data of suspended sediment load of 432 sites from various river systems of the country, out of 1,157 gauge and discharge sites functioning at present, and serves as a central pool of information in connection with various irrigation and power projects. Table 18.6 gives the number of sites for which data on sediment load of rivers are available with the CWC. One site (not mentioned in the Table) located in Nepal collects information about the Kosi river system.

TABLE 18.6

Number of Sites for which Sediment Load Data are Available[1]

State/Union Territory	Total number of sites	Number of sites and period for which sediment data are available			
		0-2 years	3-5 years	6-10 years	More than 10 years
1	2	3	4	5	6
Andhra Pradesh	26	2	23	1	..
Assam	80	15	17	40	8
Bihar	32	3	3	25	1
Delhi	2	2	..	..	..
Goa	9	6	3	..	..
Gujarat	7	4	3	..	..
Jammu & Kashmir	24	6	11	7	..
Kerala	2	..	2	..	..
Madhya Pradesh	19	6	9	3	1
Maharashtra	65	23	32	10	..
NEFA	2	..	2	..	..
Manipur.	2	1	1	..	..
Nagaland	1	1	..	..	..
Orissa	9	9	..	..	..
Punjab	29	15	7	7	..
Rajasthan	5	4	1	..	..
Tripura	4	..	2	2	..
Uttar Pradesh	43	18	13	12	..
West Bengal	67	15	40	12	..
	428	130	169	119	10

18.4.10 It will be seen from Table 18.6 that the available sediment data are meagre. About 300 silt observation posts have been established under the Centrally sponsored scheme by the State Forest and Agriculture Departments and Soil Conservation Divisions covering catchments of 21 river valley projects. The main objects of these observation posts are to locate silt contributing areas requiring priority conservation treatments and to evaluate their effectiveness. In the Damodar Valley catchment, priorities fixed earlier according to the aerial photographs and soil surveys have been revised on the basis of silt studies. Similarly, silt data have been utilised for fixing priorities in the Hirakud catchment in Madhya Pradesh. Considerable variations exist in the methods of collection of silt data by different State agencies and others because standard procedures are not

1 Data obtained from Central water Commission, Ministry of Agriculture and Irrigation, Government of India.

being followed. It is possible that inaccuracies in observed data leading to lower siltation rate computations have been responsible for underestimates in the design of the river valley projects. Attempts have been made to arrive at realistic values in respect of 36 important stations in different parts of the country after elimination of the errors. The results of analysis show that the corrected rates are considerably higher than the observed rates by anything upto 150 per cent (Appendix 18.5). In this analysis, correction factors have been applied after counting for the sampling error, and for unmeasured bedloads of the stream. The rates do not indicate the large inflow of sediment that gets into the reservoir above the critical velocity in the river/stream. For example, records of such observations in Barakar (Damodar Valley Catchment) show that one flood over two days carried as much as ten times the corrected sediment load.

5 APPROACH FOR THE FUTURE AND PROGRAMMES

Soil and Land Use Survey

18.5.1 In any developmental work related to the broad field of agriculture adequate knowledge of the soil is imperative. In Section 2 reference has been made to some rough estimates, based on certain general assumptions, of the extent of area subject to different degrees and types of soil erosion. From the progress of soil conservation programmes in the States, summarised in Section 4, it has been observed that in many States soil conservation works have been executed without prior soil survey and without due regard to interpreted land capability. Some of the States have soil survey organisations, but the facilities in respect of equipment and trained personnel are meagre, while others have no such setups. It is recognised the world over that for the execution of a long term programme of soil conservation and for sustained use of land for enhanced crop production, a soil and land use survey is essential.

18.5.2 Our Interim Report on Soil Survey and Soil Map of India dealt with in detail the present status of soil survey in the country, the organisations involved in the work, programmes for soil survey, classification and mapping, and the relevant financial implications. The following recommendations made in the Interim Report are reiterated :

(i) in conformity with the international standard, a soil map of India in the scale of 1:1 million is considered necessary and adequate;

(ii) the comprehensive system of soil classification developed by the United States Department of Agriculture (USDA) should be suitably modified, where necessary, and adopted and brought in line with the international system of soil classification (as adopted by Food and Agricultural Organisation/FAO);

(iii) expeditious measures should be taken to prepare the soil map of India in 1:1 million scale and to organise additional 170 soil survey parties in accordance with the specific requirements of the States and the Centre, and to place necessary facilities at their disposal. Aerial photographs, at least for the non-sensitive areas, should be made available for accelerating soil survey work;

(iv) the All India Soil and Land Use Survey Organisation which is at present charged with the training of soil survey personnel and soil correlation and classification at the national level, should be appropriately strengthened. An integrated training course in collaboration with the Indian Photo Interpretation Institute of the Survey of India should be organised;

(v) the State soil survey organisations should be strengthened with properly trained personnel in order to carry out all new surveys as well as resurveys on the standard pattern;

(vi) a close liaison between the Central and State soil survey organisations is imperative. For this purpose, the State coordination committees, wherever formed, should be activised, and wherever not yet formed, should be constituted as early as possible; and

(vii) State coordination committees should utilise the existing data on soil survey for land use and crop planning after due interpretation.

In accepting these recommendations the Central Government has sanctioned as part of the Fifth Plan the establishment of a Directorate of All India Soil and Land Use Survey under the ICAR with 120 field parties and other supporting staff distributed over six regional correlation centres.

18.5.3 Soil characteristics determine the nature and extent of erosion. A starting point for the determination of basic erosion rate is, in fact, one of the criteria for the classification of soils into comparable soil units. These soil units are actually a collection of correlated soils with similar erosive characteristics. So far little work on correlation of the 500 and odd soil series identified in various parts of the country has been done and hence their classification into units

has lagged behind. The programme of soil survey should include classification of recognised soils into hydrological and erodibility units in order that soils producing sediment get quickly identified. In some States, soil survey organisations are yet to be established, and hence soil conservation is reported to be planned and carried out on the basis of broad classification of lands. Progress of soil and land use capability survey is found to be slower than that of soil conservation, even where soil and land use survey organisations exist. Consequently, the latter are not as useful as they could have been for soil conservation work. Again, even where soil survey has preceded, it is observed that conservation measures are not based on soil survey recommendations. These gaps should be expeditiously bridged.

Identification of Sediment Sources

18.5.4 In view of the irreparable damage done to reservoirs by siltation, high priority should be attached to the treatment of those lands in the watershed which deliver the largest amount of sediment to the reservoirs. Delineation of such lands would help formulation of suitable programmes for reducing downstream sediment yield. The sediment sources include cultivated lands, pasture and forest lands, road banks and ditches, stream channels and banks, flood plains, gullies and others. An examination of aerial photographs would often reveal places of severe erosion and channels carrying the heaviest load of sediment. The Ministry of Agriculture and Irrigation[1] has developed a rapid method for demarcation of priority areas and watersheds for soil conservation programmes in river valley projects with the help of aerial photographs, followed by adequate field check and mapping of various erosion intensity units. In the Damodar Valley catchment the priorities fixed with the help of aerial photographs have been subsequently revised on the basis of measured silt load of rivers/streams. Photointerpretation has to be subjected to field checking. Aerial photointerpretation in regard to erosion has been completed for 0.19 million sq. km. by 1971-72, but even these data are without supporting information like rate of erosion etc. from different types of watershed. A time-bound programme, therefore, needs to be drawn up for the aerial survey of the remaining catchment area and for correlation with sediment inflow and its transport via rivers and streams and delivery into reservoirs. This would help better identification of priorities for treatment.

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1 1972. Demarcation of priority watershed for soil conservation programmes in river valley (memeographed), New Delhi. Ministry of Agriculture, (Soil Conservation Division).

18.5.5 Sediment yield of a given area varies with the pattern of precipitation, soil cover, land use and land characteristics. Rainfall and correlated runoff are primary factors which cause differential erosion depending on the vegetative cover and other land features. The erosive power of rainfall depends upon its intensity, duration and frequency. Long duration rainfall of low intensity is less erosive than intense short duration torrents. As has been stated earlier, the planning of watershed management would require quantitative estimates of management benefits for the calculation of which a set of minimum basic data has to be ensured. Of these, the data on rainfall are the most important.

Raingauge Data

18.5.6 In India a large coverage of raingauges exists but unfortunately data from nearly half of those are not readily available. The total number of raingauges is estimated to be well over 8000 excluding those that have recently been installed by government blocks and non-government agencies like tea gardens and other plantation estates etc. Out of these, data are received only from about 5000 raingauges by the India Meteorological Department. A recent scrutiny of 5,561 gauges carried out by the Directorate General of Observatories has brought out that 117, i.e., only 2 per cent of the above number inspected have no installation or exposure defects; out of the rest some are either unserviceable or non-standard. Assuming that all the 500 departmental gauges are good, a total of 617 gauges produce reliable data. For a country of the size of India, the number is definitely inadequate. Publication of rainfall data by States is in arrears of 3—6 years and in some cases of as long as 15 years. Self-recording raingauges are few, the highest number being installed in the Damodar Valley catchment hardly a decade ago. In addition, data are available for a limited number of stations for the India Meteorological Department (IMD) and a few more established during the last 5 years or so under the centrally sponsored scheme of watershed management. The IMD has recently put out a short duration frequency data in respect of a few intensities. When those data are examined for practical application along with data collected locally, they do not bear the minimum scrutiny that is necessary for reliable estimation. According to the World Meteorological Organisation (WMO) the following ranges of precipitation station network (Table 18.7) for measurement of surface flow have been recommended.

TABLE 18.7

Ranges of Precipitation Station Network according to World Meteorological Organisation

Type of region	Range of norms for minimum network (area in sq km for one station)	Range of provisional norms tolerated under difficult conditions (area in sq km for one station)
Flat regions of temperate, moderate and tropical zones	1,000 to 2,500	3,000 to 10,000
Mountainous regions	300 to 1,000	1,000 to 5,000

These ranges would appear to have taken care of climatic variations responsible for differences in rainfall over wider areas but do not seem to meet the requirements of small watersheds. In the context of these figures the inadequacy of rainfall data is obvious. To remedy the lacunae the following measures are obligatory:

(i) location of all raingauges should be ascertained, if necessary, by a special scheme within two years;

(ii) all non-standard raingauges should be replaced with standard ones;

(iii) IMD's plan for installation of 1,200 additional raingauges on the basis of WMO's recommendations should be re-examined;

(iv) a special unit should be established in the IMD with powers and responsibilities and suitable financial assistance to instal additional network of raingauges, and collect and publish all available data within a period of 3 years;

(v) correction factors applicable to all the defective raingauges should be determined as early as possible; and

(vi) a minimum network of self-recording raingauges as would enable publication of maps of short duration rainfall and frequencies within a period of 10 years should be established.

Conservation Programmes for the Plains

18.5.7 In a number of States soil conservation programmes are taken up on an *ad hoc* basis during the period of drought for providing work and succour to the distressed. Large funds are made available from governmental or other sources and generally contour bunding programmes are executed as a measure of improved moisture conservation. On a long term perspective they are rarely beneficial.

Moreover, as soon as the drought conditions disappear, whatever conservation work has been executed languishes in the absence of any maintenance programme. Unless preceded by proper survey and planning, execution of soil and moisture conservation programmes would not be effective.

18.5.8 The problems of soil and moisture conservation are many. There are, however, a lot of limitations in the matter of execution of the programme e.g., lack of adequately trained personnel as also finance to tackle the problems in an integrated manner. It will, therefore, be necessary to assign priorities to practices and areas that lend themselves to immediate high production and favourable benefit/cost ratio. On the basis of the points mentioned above the areas may be divided into the following broad categories :

(i) command areas of river valley projects ;
(ii) catchment areas of river valley projects ;
(iii) rainfed agricultural lands ; and
(iv) other areas, such as pasture lands, forest lands, wastelands etc.

Soil and moisture conservation in command areas of river valley projects should undoubtedly receive the first priority. The treatment of these areas would not only result in immediate high returns but also make it possible to utilise the entire irrigation potential created by incurring heavy capital expenditure. All-round development of command areas has been adequately dealt with in Chapter 16 on Command Area Development. Land development including levelling and land shaping, as part of irrigated agriculture, essentially conserves the soil. Moisture conservation in irrigated areas is essentially one of water management. These two aspects are also suitably discussed in Chapter 16. The life of a reservoir depends on the extent of silt being brought by runoff from the catchment areas and deposited therein. Treatment of these areas by conservation measures would not only result in better benefits to the people inhabiting these areas but also help in prolonging the life of the reservoir. It is obvious that they should receive the same priority as the command areas.

Rainfed Agriculture

18.5.9 Of the total area of 109 Mha (Table 18.2) under rainfed cultivation about 31 per cent fall in the high rainfall (1,150 mm and above) region, 34.5 per cent in the medium rainfall (750 mm to 1,150 mm) region and the remaining 34.5 per cent in the low rainfall (upto 750 mm) region. It is in the latter two regions that cropping efforts suffer because of poor returns and great instability. This situation drew governmental attention as early as the eighties of the

last century when the Famine Commission recommended protective irrigation but this was possible only to a limited extent. It was, however, realised that soil and moisture conservation would, to a great extent, help in overcoming the uncertainties and inadequacies of rainfall. Researches on dryfarming practices aimed at increased moisture conservation for the use of growing crops have been in progress for more than 30 years and certain useful practices for soil and moisture conservation have been developed.

18.5.10 In many dry areas, land is very undulating as a result of erosion of different kinds over a long period of time. Erosion thus creates differential topography of flats, slopes and valleys, which adds to the problem of soil and moisture conservation. In each of these classes, conservation measures would vary and it would be necessary to introduce some basic soil and moisture conservation measures before the other components of the new farm technology could be successfully introduced. For doing this, consolidation of landholdings is a prerequisite. Soil characteristics play a dominant role in soil and moisture conservation as water infiltration and transmission are dependent on the physical properties of the soil both at the surface and subsurface regions. Incidentally, in the dry areas a large extent is occupied by deep and medium black soils characterised by high contents of montmorillonitic clays. The swelling nature of these clays and their high percentage in the soil render infiltration of rain water through the surface and its transmission to lower depths difficult. Even though such soils have high retentive and storage capacity, conservation becomes a problem. This is because water stagnates and thereby growing crops are adversely affected. There are other types of soils in these areas, particularly red soils, which have distinctly different physical characteristics. Being lighter in texture and constituted of secondary minerals mostly composed of kaolinites, water infiltration and transmission becomes favourable. As a result moisture conservation measures succeed. It is, therefore, recommended that due consideration should be given to the physical and morphological characteristics of soils in the development of precise techniques for soil and moisture conservation. Wherever possible, the physical properties of the soil have to be improved so as to facilitate infiltration and transmission of the rain water. The methods of improving physical properties of soil and soil structure are broadly known, but in a specific situation further studies may be required.

Bombay Dryfarming System

18.5.11 In Maharashtra considerable work on soil and moisture conservation in dry areas has been done. A package of practices

known as the 'Bombay Dryfarming System' conserves soil moisture and ensures crop production[1]. It consists of contour bunding for prevention of runoff and soil erosion; deep tillage once in three years; surface tillage by harrowing four times at monthly intervals during and after the onset of monsoon; addition of bulky organic manures once in three years; low plant population per unit area through wider spacing (45 cm between rows) and low seed rate (4.5 kg of sulphur treated seed of jowar per hectare); interculturing four times during the crop season; rotation of jowar with gram; crop mixture of jowar with safflower or linseed and fallowing. It is of utmost importance that for realising maximum benefits the package of practices in dry areas should be adaptable to different soil and climatic regions. There should be a selectivity of approach and the practices should provide reasonable opportunities for maximum conservation of moisture and its utilisation. Individual practices developed by scientific experimentation are rarely acceptable if they do not ensure increased output of crops. When different practices like better tillage, soil and moisture conservation, better varieties and better nutrition are made to interact, yield and income per unit area are likely to be higher. The economics and benefits of soil and moisture conservation measures in different soil and climatic regions have been discussed earlier in paragraphs 18.3.1 to 18.3.5.

Farm Ponds

18.5.12 Studies conducted in the dry regions of Maharashtra where meteorological conditions are uncertain and erratic have shown that out of the total rainfall only 10—20 per cent is available to crops, the rest being lost as runoff, drainage, evaporation etc. Having regard to this fact, and under conditions of erratic and scanty rainfall of about 500—680 mm in the scarcity zone, it would appear that there is a serious limitation of water and good yield of cereal crops like jowar or bajra cannot be expected. There is a possibility of increasing the yield of crops provided water availability is augmented by adoption of suitable engineering and cultural methods. Field trials have shown that increased crop yields to the extent of 33—70 per cent may be achieved by adoption of soil and moisture conservation methods. Even after adoption of usual moisture conservation practices, there are periods when the moisture depletion reaches a critical limit, thereby adversely affecting the crop. In such a situation it becomes necessary to make water available for saving the crop from deterioration or failure. This can be achieved by taking recourse to water harvesting, a good instance of which can be found in the construction of farm ponds. The

1 Kanitkar, N. V., *et el* (1960) Dryfarming in India, ICAR, New Delhi.

technique is developed for farms of 4 to 5 hectares where water is stored in a tank at the lowest level by diverting all surface runoff by laying the plots into contour strips. The stored water in the tank is useful in giving supplementary irrigation and thereby increasing the yield of crops from a portion of the farmed area of the catchment. The technique can be studied and further developed and followed in different regions after suitable modifications, wherever necessary. Water harvesting technique would also involve increasing the runoff by reducing soil permeability by mechanical and chemical means.

Other Water Conservation Measures

18.5.13 Experiences in different parts of the country on the practices such as contour cultivation, contour bunding, field bunding, levelling, various types of terraces, especially conservation bench terraces, have shown that conservation of rain water and proper utilisation of the conserved moisture are possible and crop yields can be substantantially increased. It is, therefore, emphasised that the rain water in such regions should be conserved to the maximum extent possible both in the soil profile and surface storages. Practices like nallah bunding, water spreading, water harvesting from part of the area and utilisation in the remaining area, village tanks, renovation of old tanks should receive urgent attention. For proper utilisation of conserved and stored moisture, mulching, deep placement of fertilisers, training roots to tap deeper layers using suitable crop varieties, weed control, interculture etc. should be resorted to according to the specific situation.

Agronomic Practices in Rainfed Areas

18.5.14 In the dry areas, soils suffer from nutrient deficiency, particularly of nitrogen. If good crops are to be grown and conserved moisture efficiently utilised, it would be necessary to supply nutrients in adequate measure. Band placement of fertilisers in subsoil layers is one very good method of helping the roots to go deep for exploiting the conserved moisture. In addition to this, foliar feeding at the time of grain formation is a potent method of supplying nutrients under dry conditions. Mixed farming has immense possibility in the dryfarming areas. Alternating grass and crop varieties is an important measure of soil conservation and moisture preservation. Therefore, in the multiple cropping programmes, grasses should find a place.

18.5.15 Conservation measures on lands subjected to rainfed agriculture and others including waste lands, grazing lands, sloping lands, gullied and ravine lands, should be similarly taken up within a reasonably short period. States should accordingly build up their soil con-

servation organisations and resources. Lands under dryfarming should be brought under such conservation measures as contour cultivation, strip cropping, etc. as they do not involve any capital expenditure or high technique. In spite of the best efforts to increase the extent of irrigation the bulk of agriculture in the country would continue to be under rainfed conditions. The most important limiting factor to good agriculture in such a situation is soil moisture. Over large areas the total annual rainfall is below 1000 mm and that too concentrated in 3-4 months of the year. Even in areas of higher rainfall dry conditions prevail for a major part of the year. A paradoxical condition obtains in the sense that even though the total annual rainfall can sustain two or more crops in the year, the pattern of it is such that hardly one crop subsists. The latest advances in the technology of dryfarming put maximum stress on the soil and moisture conservation practices such as tillage operations with suitable agricultural implements, various cultural practices, bunding, construction of small tanks and reservoirs to conserve rain water and runoff thereby increasing subsoil moisture and groundwater recharge. These are the basic practices on which others like introduction of short duration crops, foliar spray of nitrogenous fertilisers etc. can be superimposed.

Treatment of Private Degenerated Lands

18.5.16 There are private degenerated lands where the owners often fail or are unable to take effective measures of soil conservation. With the enforcement of land ceiling in all the States the extent of such lands under any individual ownership may not be high, but in a given catchment there may be a sizeable extent of such degenerated lands, which will continue to be the foci of erosion unless provision is made for the conservation of subsoil water or the prevention or mitigation of erosion on such lands. In some cases, such lands might have been kept out of cultivation on consideration of several factors including farming being uneconomic. In the draft model Soil Conservation Act circulated to the States, it is provided that the State Government may declare such areas to be notified for the purpose of preparing land improvement schemes. For the uncultivable lands, the scheme may include provision for planting and preservation of trees, shrubs and grasses or providing shelter belts against wind or sand or for any other purpose. Reclamation, including afforestation of such lands is provided for in the model Act. The model Act includes, in addition, obligatory maintenance and repair of any afforestation works that may be carried out as a part of reclamation or land improvement. Where such lands belong to individuals, the approach proposed for farm forestry in our Interim Report on Social Forestry may be followed, and

the forest departments may provide for the necessary technical support through their extension organisation that may be set up. Where the wastelands or degenerated lands belong to Government or panchayat or constitute village commons, the work may be carried out by the forest departments in the manner recommended for mixed forestry in the above Interim Report. It should be borne in mind that for mixed forestry to be successful there should be a reasonably compact area of 20 hectares or more available at one place, and that it is possible to associate the panchayats with the protection of mixed forests so created.

Conservation Measures in Sloping Lands

18.5.17 Where siltation rate in the catchment of a proposed reservoir sufficiently high, the economics of the project should be worked on the basis of the prevalent siltation rate and thereby the economics of loss in the irrigation command. This economics has to be considered against investment in quick conservation measures for the catchment area to bring down siltation to a reasonable level and thereby planning for a regimen with larger storage. As reservoir sites are few, wherever a good site is found it is in the national interest to ensure that the catchment soil conservation is taken up simultaneously with the reservoir construction so that the life of the reservoir may be long.

18.5.18 Considering the magnitude of the problem and the number of different soil and moisture conservation measures that have to be undertaken in the catchment of a reservoir and looking at what has been achieved during the last two decades, one may be inclined to treat the problem as insurmountable. In our opinion, such a pessimistic attitude can arise if soil and moisture conservation in the catchments of reservoirs is taken as a programme only benefiting the reservoir and its capacity. If the problem is looked at in the broad context of proper land use in the country for maximising production under the agroclimatic conditions and soil conditions of a region, the entire outlook will have to change. We would urge that instead of treating this problem merely as one of saving the life of reservoir, the nation should look at it as a part of programmes for maximising land use. All that is necessary is that these programmes are drawn up in a coordinated manner in the catchment areas of reservoirs on a priority basis so that the additional benefit of reservoir rehabilitation can be obtained.

Afforestation

18.5.19 The importance of forests and afforestation in preventing erosion of soil and siltation of rivers and streams has been emphasised in chapter 41 on Forest Policy. It has been mentioned therein that

protective influence of forests in localities vulnerable to erosion and degradation should be brought to bear in full by suitably managing the existing forests and providing for their rehabilitation. This would ultimately lead to maintenance of water balance, control of erosion, prevention of rapid silting of reservoirs and moderation of floods. Considering the limited forest area available in catchment areas of river valley projects, it is all the more necessary that every bit of degraded forest land should be brought back to proper condition. Afforestation of degraded forest lands has been accepted as one of the programmes to be taken up in the upper catchments of river valley projects. The effort in this direction has to be intensified. The maintenance of forests or the development of the same in degraded forest areas of the catchment can be taken up either as a programme of commercial forestry as suggested in our Interim Report on Production Forestry-Man-made Forests, or as a social forestry programme for improving fuel wood and timber supply to the villages as suggested in our Interim Report on Social Forestry. Both these programmes are going to be implemented in the country. If done in catchment areas, a substantial portion of soil conservation problem may be surmounted. One of the difficulties in the proper conservation of forest lands in catchments of river valley projects is the presence of extensive rights and privileges of villagers for grazing and for collection and use of forest produce. It would be necessary not only to regulate their rights and privileges but also to supply their requirements of forest produce in such a manner that the important role of forests in conserving soil and moisture is not lost sight of. A fuller discussion on these aspects has been made in Chapter 42 on production and Social Forestry and in Chapter 45 on Forest Production and Law.

Grass Production

18.5.20 Experience has shown that grass production is an important activity for the rehabilitation of degraded areas in the catchment. It has also been found that such grass growing has been profitable and has led to the development of pastures only where marketing facilities have been provided. The nation is embarking on a large scale commercial milk production programme and also sheep breeding programme. In these contexts, it has been suggested that grass reserves should be created in forest areas and community lands. By a suitable linkup of the programme of milk production with the creation of grass reserves in the catchment of reservoirs, production of grass will become an economical venture and hence the maintenance of such reserves is assured. At the same time this will solve the problem of soil and moisture conservation.

Conservation for Productivity Increase

18.5.21 Experience has also shown that contour bunding and other soil conservation measures taken up on cultivated lands in the catchment have led to greater productivity. The investment becomes economical where the productivity increase is reasonable. If areas showing such economic rise in productivity are identified in catchment areas and an institutional programme of credit is developed, the farmers should be able, in their own interest, to take up soil conservation measures on their lands. It is in the interest of the nation to ensure that such programmes are developed and farmers enthused to carry out the programmes in catchment areas of reservoirs on a priority basis. There may be marginal areas where some amount of capital subsidy may be required to ensure viability. The nation is already subsidising in many States soil conservation programmes in varying degrees. Such programmes may be utilised for dealing with these marginal cases. If identification of running programmes for implementation in catchment areas is done on a priority basis, such areas as do not respond in terms of increased productivity to conservation measures may be minimised and covered by a catchment area soil conservation programme in the interest of the reservoir. Thus, the problem of direct investments by the State may be substantially minimised. We, therefore, recommend that soil and moisture conservation measures in catchments of reservoirs should be taken up as an important part of improved land use programmes. The various land use programmes should be so coordinated that additional funding required for completing the process of soil and moisture conservation is minimised. We would also recommend that after the minimum involvement which may be of economic return to either forestry or agriculture, a phased programme for direct investment by the States to save reservoirs from siltation should be taken up.

People's Participation

18.5.22 The Irrigation Commission assessed that about Rs. 800 crores would be required to take up corrective measures in the catchment areas of 35 river valley projects. Owing to rise in operation costs, a correspondingly higher estimate would be in order. The cost of construction and management of the large number of watershed projects under construction and contemplated for the future is bound to be enormous. To this must be added the cost of maintenance which is going to be higher as well. In works of this nature covering wide areas and involving a large number of people, extensive participation of the people at the district, block and village levels would ensure superior

performance and higher achievements. The ownership of the land, except in the higher catchments, being by and large private, people's participation at all levels is all the more desirable, especially in the maintenance programme. In view of the huge cost involved in watershed protection, it may be beneficial to localise various plan programmes so as to tackle the problems of catchment areas. In the matter of maintenance, the farmers should be educated about the need of investment in soil and moisture conservation measures for better agriculture.

Inter-State Projects

18.5.23 Out of 29 large storage projects including those under construction with a total storage capacity of 10.26 mham, only 5 covering 1.45 mham are single-State projects. All the others concern two or more States. There are still others with catchment area of 1000 sq km and above and storage of 12.5 thousand ham and above which are of inter-State character. In the case of Mayurakshi and Machkund projects the catchment and command areas are entirely in two different States. A review of the large number of medium projects under construction upstream of the 29 large projects would further illustrate how their hydrology concerns more than one State. The classical example is of Madhya Pradesh which accounts for more than 33 per cent of the catchment area of most of the major projects under construction in the country. Once all the medium projects numbering about 500 are completed, it will perhaps be impossible for any State to be independent of the hydrological situation in the river basins concerning its projects. By and large, therefore, it would be advisable to treat all storages with a hypothetical limit of 12.5 thousand ham and above as having inter-State implications. Accordingly, most of the watersheds in the country are inter-State in character and it is likely that the water resource development projects are situated in one State and the watersheds are distributed in the neighbouring States. In such a situation, the Centre should provide financial and supervisory assistance for the watershed management. Since the benefit accrues directly to the States in various ways, such projects should be financed by the Centre and the States concerned, as is prevalent now, namely, 50 per cent as grant and 50 per cent as loan.

Documentation of Silt and other Data

18.5.24 It has been mentioned earlier in paragraphs 18.4.9 and 18.4.10 that on account of many gaps, inaccuracies and sketchy nature of silt data available in the States, full utilization of these data

has not been possible. In spite of standardised procedures, uniformity has been lacking in silt data collected by different agencies. Moreover, owing to dispersal of data centres retrieval has been difficult. The work of gauging silt and discharge of various rivers and their tributaries should, therefore, be a central responsibility. Adequate funds should be provided for the purpose. A similar view has been expressed by the sub-committee of the National Committee on Science and Technology on sedimentation and watershed management.

18.5.25 It has been observed that particulars of watersheds of existing river valley projects are not available in the project reports except some general references to the characteristics of the watersheds. In the case of completed projects, the changes that are taking place in the watershed are not systematically recorded which would have enabled corrective measures to be taken, where necessary. Generally, the storage projects which were completed decades back have been adversely affected due to excessive siltation. In these circumstances, it is recommended that particulars such as soil characteristics erosion, vegetal cover, land use changes, climatic components including rainfall pattern, etc. of the watersheds should be continually collected and systematically studied in order to take corrective measures. For river valley projects which are situated in more than one State, the data should be collected by the Ministry of Agriculture and Irrigation with the assistance of the concerned States, analysed and stored in one place for the benefit of users.

Watershed Management—an Integrated Approach

18.5.26 The watershed management is a complex affair, and as such it is expedient to separate the watersheds into a number of units of control, i.e., subwatersheds. The size of the subwatersheds would vary depending on the hydrological control measures that can be installed. Further, this would facilitate adoption of measures in a selected manner and at the same time their evaluation. The earlier practice of considering big subcatchments of a river valley project running into several hundred square kilometres as the unit was hardly helpful in determining priority areas. Priorities may be based on the actual or estimated sediment yields. There is, however, a limitation to subject all the watersheds to this direct method. It, therefore, becomes necessary to use the available data on hydrology and sedimentation and project the same into the ungauged areas with as much accuracy as possible. The need for more data has been realised and action taken by the Central Water Commission. As data accumulate from a variety of watersheds, methods and procedures have to be refined to enable

allotment of more accurate indices to each parameter of sediment production. As already mentioned in paragraph 18.4.9, discharge observations are being taken at 1157 sites out of which sediment data are being collected at 432 sites only. More such sites are likely to be set up to cater to the needs of future projects. Even then the number is too small and hence the location of gauging stations should be planned carefully to cover all major situations. In view of the urgency and importance of sediment data, it should be made obligatory on the part of all the discharge observation sites to obtain sediment data as well. The accuracy of data depends upon the sophistication of equipment, the frequency of observations and checks, but it may not be possible to adopt the best standards at all the sites. However, at least 10 per cent of the observation units to be run by the central agency should be 'A' class stations. By correlating the observations taken at such 'A' class stations with those of the remaining stations, the accuracy of information obtained in the latter should be improved as in 'B' or 'C' class stations. The available techniques for the measurement of suspended silt load and bed load rolling with the river flow should be improved on the basis of research work.

18.5.27 The condition of the watershed and its management have a bearing on (a) runoff volume, (b) rate of discharge, and (c) rate of sediment load. A knowledge of all the three sets of data is, therefore, necessary to plan effective watershed management operations. Ideally, the watershed management should start earlier. This, not being possible in practice, should at least be initiated simultaneously with the execution of the project itself. By doing so, stabilisation of the watershed is achieved earlier, thereby putting the water resource development project on a firm basis. This integrated approach consists in (a) designing and constructing major engineering structures, (b) taking measures for sediment control, and (c) taking measures for land erosion control. A review of projects is needed to find out which of the above factors dominates, so that timely and proper management measures may be adopted. While considering the watershed management of river valley projects, it would be necessary to identify those tributaries which are responsible for more silt load in the rivers than others. In this way areas to be treated for conservation purposes may be selected on a priority basis. The watershed management programme is aimed at not merely prolonging the life of a river valley project but also to save the valuable soil, which once lost, is gone for ever. It is, however, a programme distinct from the general soil conservation works and requires careful survey, planning, priority determination and a different strategy of action. Priority determination cannot be done by a study of the watershed factors alone and assigning arbitrary indices of sediment production and delivery. Priority determination should be

based on sediment yield and experience in similar catchment areas. The treatment strategy essentially consists in controlling sediment deposition, followed by land treatment measures like bunding, terracing and afforestation.

18.5.28 It is desirable that whenever water resource developments are contemplated and executed, watershed management should be initiated simultaneously. The watershed management being a process of overall land use, land improvement and sedimentation control may even be independently executed because of the accrued benefits, and need not be tied with water resource development projects. There is need to evolve a yardstick for calculating benefits of overall land improvement and sediment control. At present, water resources development projects are handled by one organisation, whereas watershed management projects are handled by another. But the two are so intimately related that whenever a water resource development project is planned, the authority responsible for watershed management should be simultaneously associated, so that both works run complementarily and parallelly. The appraisal of the progress highlighting interdependence of the two projects should be made annually in a systematic way so that corrective measures are taken timely and the benefits are maximised.

6 ORGANISATION AND FINANCING

18.6.1 At present soil conservation in the States is carried out as one of the independent activities of either the Agriculture Department or the Forest Department. While in some States like Bihar and Punjab, there is one officer of the rank of Director, Soil Conservation, in most others, the soil conservation programmes are looked after by an officer of the rank of Additional or Joint Director of Agriculture. The activities in the States are, in general, built round works related merely to contour bunding and terracing. In most States with the possible exception of Uttar Pradesh, there is no specialist staff either at the State or the divisional level, who could make proper assessment of soil and moisture conservation measures and help farmers solve problems of soil deterioration and water waste. There is also none to carry out functional field inspection of various programmes and practices in respect of their technical adequacy and working efficiency. In most of the States at the headquarters level there is no planning cell to collect and compile data on the problems, achievements and benefits of soil conservation. There is no Specialist at the State level to provide information and publicity in regard to soil conservation and to bring out extension

material for farmers and others. For a comprehensive planning and effective execution of soil conservation programmes, it is necessary to strengthen the organisation adequately, to meet the requirements of a coordinated programme of conservation, use and management of soil and water. In order to effectively plan and implement the soil conservation programme on the lines indicated above, it would be necessary to have technically competent and numerically adequate number of personnel at all levels.

18.6.2 In view of the constant shifting of technical staff from one area to another and the emphasis laid on treating additional area every year to achieve the prescribed targets, provisions regarding maintenance have not been enforced fully. This has resulted in areas treated earlier reverting to their original condition within a few years. The practice of frequent shifting of technical personnel from one section to another should, therefore, be examined in the light of the situation mentioned above and be preferably stopped. It has to be recognised that soil and moisture conservation is a continuing programme and needs continuous follow up and maintenance. The jurisdiction of an Assistant Soil Conservation Officer should be fixed and he should be required not only to tackle fresh problem areas but also to maintain the areas already treated. An area treated once with physical measures like terracing etc., can be taken up for fresh treatment after 5—7 years depending on the condition of deterioration. It is obvious that measures, if taken timely, would be comparatively less intensive and also less expensive.

Inter-Directorate Committee on Soil Conservation Works

18.6.3 In matters of coordination policy decision and execution State soil conservation boards serve a limited purpose. The Central Soil Conservation Board which started functioning in 1953 was subsequently abolished. In a few States like Maharashtra, Jammu & Kashmir, soil conservation boards do not exist. In Maharashtra, however, there is land improvement coordination committee at the district level. The Model Act provides constitution of the board at the State level to take decisions on policy matters and give necessary guidance for the execution of the programme at the operational level. All departments directly or indirectly involved in the conservation and management of soil and water resources in a State are associated with the board. Most of the States have constituted the board. The programmes under each of these departments, if not executed jointly with the Soil Conservation Board, may, perhaps inadvertently lead to increased erosion, obstruction of natural drainage and destruction of vegetation. Because of the multi-disciplinary nature of soil

conservation measures, the departments concerned have to be involved. But the Board consisting of Minister-in-charge of Agriculture as the Chairman, and four members of the Legislature, the Chief Engineer for Irrigation in the PWD, Heads of Forest and Agriculture Departments and the Secretary to the Department of Agriculture as the Secretary of the Board is no doubt a high powered body but perhaps not the right one to launch a multidisciplinary action programme on soil conservation. Instead, an inter-directorate committee presided over by the Agricultural Production Commissioner (Chapter 62 on Administration) may take up soil conservation on a coordinated basis and as a special action programme. In that case the Board may simply have a policy making function.

Financing Soil Conservation Works

18.6.4 The financial assistance for carrying out soil conservation works given by the Centre to the States is in the form of loan, grant and subsidy. Some States utilise the subsidy towards cost of establishment etc. for soil conservation works. The State Governments do not have adequate funds if the cost of soil conservation incurred by Karnataka and Maharashtra is an indication. Out of the funds made available in the form of loans, programmes in most of the States are being drawn up and executed. It should be the responsibility of State Governments to execute soil conservation works initially at Government cost. Adequate funds should, therefore, be provided in the annual budget. The State Governments should have the further responsibility to suitably and effectively phase the execution of soil conservation programmes over a reasonable period.

Recovery of Cost of Soil Conservation Works

18.6.5 In some States the procedure followed in respect of recovery of contour bunding dues is that as soon as the works are completed, recovery statements are prepared and sent to the Revenue Department. The Revenue Department enters the same in the village revenue records against the lands in which soil conservation works are executed. The recoveries of bunding dues are made in 10-15 annual instalments as arrears of land revenue. In some States, the cost of bunding works is treated as *taccavi* loans and the same is recovered in a number of instalments already fixed. Preparation of recovery statements is a cumbersome work entailing time and staff. Watching the recovery of instalments is equally tedious. Some having experience in the execution of soil conservation works are of the view that this procedure should be done away with. The alternative procedure suggested is

to increase the land revenue of such lands in which the soil conservation works are executed to such an extent as to cover the interest on the recoverable cost. The interest amount so worked out should be the increase in the land revenue assessment of the land in which the soil conservation works are executed. If merged with the land revenue, the income in several places would go to local bodies and thereby the State does not get the return on the investment. It is, therefore, recommended that the amount due from each landholder should be recovered in a suitable number of instalments depending on the nature of operations and cost involved. The number of instalments may be made conveniently larger in case of small and marginal farmers. In course of time this concession should apply to marginal farmers only. The collection may be in addition to the usual rent roll and it would not create any particular accounting difficulty. The procedure is truly applicable to cultivated lands in the catchment areas and in the command areas as well. For lands in the catchment area which are suitable for afforestation and grass production, the same procedure of recovering the cost would not work. In such cases, the Forest Department should take charge of such areas in the manner mentioned in paragraphs 18.5.16 and 18.5.20 especially for privately owned degenerated lands. The Forest Department may suitably afforest and plant grasses, as part of its afforestation and conservation programme and realise part of the expenditure from the sale of either forest produce or grasses. Grass production in areas outside the jurisdiction of Forest Department and social forestry should be left to the Animal Husbandry Department.

Soil Conservation Act and Legislation

18.6.6 Acting on the directives issued by the Government of India from time to time, most of the States have enacted legislation for the conservation of soil and water resources in the States. A study of the Acts received from 9 States, viz., Uttar Pradesh, Punjab, Madhya Pradesh, Rajasthan, Bihar, Maharashtra, Karnataka, Jammu & Kashmir and Kerala indicates that uniformity has not been maintained in all the States in the Soil and Water Management Act. Soil conservation measures cannot be effective if the entire watershed is not simultaneously treated. The watersheds are not coterminus with the State boundaries and in order to have uniformity in their treatment, uniformity of legislation in such of the neighbouring States would be helpful. An examination of the Acts received from a few of the States has further revealed certain lacunae which have to be rectified. The procedures laid down under the various provisions of the Act are laborious and time-consuming. In order to reduce time-consuming formalities and

include some of the recent developments made in conservation technology, a re-examination of the Acts is necessary. The land consolidation Acts should make necessary provision to associate soil conservation workers so that consolidation work conforms to the land development pattern.

7 RESEARCH AND TRAINING

Soil Conservation Boards

18.7.1 Research on soil and moisture conservation received governmental attention in the thirties with the initiation of the scheme on dryfarming (vide paragraph 18.4.3). It got a real fillip in 1953 when the Government of India set up a Soil Conservation Board with the Union Minister of Agriculture as the Chairman. In view of different disciplines being involved, the Board was constituted of members from various departments, namely, the Secretary, Department of Agriculture, Agricultural Commissioner, ICAR; Inspector General of Forests; Secretary, Ministry of Irrigation and Power, Member (Waterways, Irrigation and Navigation) of the Central Water and Power Commission and Deputy Financial Adviser, Ministry of Finance. One of the main functions of the Boards, among others, was to organise, co-ordinate and initiate research in soil conservation. The Government of India also advised the States to set up similar State soil conservation boards for assessing erosion problems, to formulate policy in matters of prevention of soil deterioration and to execute soil and moisture conservation programmes. Since then, barring a few States, all others have established the soil conservation boards, which are directing the execution of programmes of soil and moisture conservation. In pursuance of its objectives the Board at the Centre established nine regional research-*cum*-demonstration-*cum*-training centres (a) to carry out research on specific regional problems with a view to developing criteria for erosion hazards and establishing standards of efficiency for the various soil and moisture conservation practices, individually and in combination; (b) to carry out fundamental research on hydrological laws governing the watershed behaviour under different management practices; and (c) to serve as demonstration centres for developing proper knowhow for soil conservation measures. These centres are located at Bellary (Karnataka), Ootacamund (Tamil Nadu), Dehra Dun and Agra (Uttar Pradesh), Hazaribagh (Bihar), Vasad (Gujarat), Kota (Rajasthan), Chandigarh, and Chhatra (Nepal). Later in 1962, one centre was established at

Ibrahimpatnam (Andhra Pradesh) to study the problems of red soils in low and medium rainfall areas. Besides, a central research institute at Jodhpur was started in 1952 as Desert Afforestation Research Station with the collaboration of the United Nations Economic, Social and Cultural Organisation (UNESCO) to tackle desert problems. It was reorganised in 1959 as the Central Arid Zone Research Institute. The research centres mentioned above are expected to concentrate on the major regional problems of the country as shown in the tabular statement below. The Hazaribagh centre is being run by the Damodar Valley Corporation in cooperation with the Bihar State Government. The Chhatra Centre is no longer with the Government of India and the Ibrahimpatnam Centre is being used as a research station of the ICAR coordinated project on dry farming. The six remaining centres are now attached as sub-stations to the Dehra Dun centre which has been renamed as the Soil and Water Conservation Research and Training Institute. The major research problems dealt with by the Centre are as under:

Dehra Dun*	—	Erosion control in the Himalayas; training of torrents; stabilisation of land slides; development of techniques for crop production; establishment of pastures and forestry.
Kota, Vasad, Agra *	—	Survey, classification and reclamation of ravines; production of crops, forage and forestry in the ravinous areas of the Chambal; the Mahi and the Yamuna respectively.
Chandigarh	—	Erosion control in the Siwaliks; training of *chos*.
Ootacamund*	—	Soil and water conservation in the Nilgiris; developing standards for construction of bench terraces for potato cultivation; development of techniques for crop production; establishment of pastures and forestry; conducting studies of hydrological conditions under different vegetative covers.
Bellary*	—	Soil and water conservation in black soil areas; development of bunding techniques in black cotton soils.
Ibrahimpatnam	—	Soil and water conservation in red soils under low and medium rainfall regions.
Chhatra	—	Erosion control in the Kosi catchment.

State Responsibilities

18.7.2 Apart from the major regional problems of research and demonstration mentioned above, there would be specific local problems

* These centres are also charged with the responsibility of imparting inservice training to gazetted and non-gazetted personnel sponsored by the State Governments.

of soil conservation which would vary from State to State or from one area to another within the State due to varying conditions of rainfall, soil, topography and economic and social factors. It is precisely in these areas of research that the States are required to fill up the gap by playing an effective role. Some States have developed minor research facilities. In Andhra Pradesh, one research station was established in 1964 at Anantapur which is functioning under the Andhra Pradesh Agricultural University. Kerala has a soil conservation research station at Konni where researches on agronomy and engineering are conducted for the purpose of evolving suitable soil conservation methods which can be popularised amongst cultivators. In Orissa some pilot studies are being made to assess the efficiency and adaptability of conservation techniques. A research centre for red soil was set up in Periakulam taluk in Madurai district (Tamil Nadu) in 1967-68 to study the effects of agriculture, agrostology, afforestation and engineering measures on conservation of soil and moisture. At Rahmankhera (Lucknow) in Uttar Pradesh the effects of either bunding or levelling alone or in combination on efficiency of moisture retention during crop growth are being studied. In Maharashtra, experiments have been laid out to develop bunding techniques for moisture conservation in various soils. The Damodar Valley Corporation established its own research station at Deochanda to develop efficient agronomic and engineering methods for the purpose of soil and moisture conservation.

18.7.3 Research organisations in the States on soil conservation are thus not many and the facilities available are meagre. The developmental work that is carried out in the various States is based on the research information collected by the Central research stations or observations or experience gained in other States without regard to the local soil and agroclimatic conditions. The central soil conservation research centres do not represent all the problem areas of the country, particularly the eastern region where heavy and intense rainfall characterises the soils and land use pattern. Further, the cultivation in hilly areas and the crop husbandry practised by the tribal people are of the shifting type resulting in degeneration of land. It is of urgent necessity to carry out pilot experiments in the *jhum* or *podu* areas and to conduct relevant research both for the sake of soil and moisture conservation as also to wean away the tribal population towards settled farming. Socio-political influence which is operative favouring continuance of the hazardous types of cultivation in these erosion prone areas has to be countered. Considerable stress is laid on research work in regard to ravine reclamation for which three central soil conservation centres, representing the differential conditions of the ravines, are in operation. This is a step in the right direction.

Follow up work

18.7.4 A critical review of the work done at the various soil conservation research-*cum*-demonstration-*cum*-training centres shows that in spite of various constraints in funds and materials and technical staff, these centres have contributed to the solution of many problems, whether engineering or agronomic, and imparted training in soil and moisture conservation to a large number of officers and assistants. The techniques and specifications evolved at these centres for bunding and terracing, check dams, gully plugs, afforestation, selection of grasses for protection of bunds and terrace walls and their introduction in grasslands etc. are mostly applicable to local conditions. These require to be tried on a wider scale so that they can cover differences in soil characteristics and other environmental conditions such as climate, topography, etc. Detailed information on the hydrological behaviour of different types of soil, their erodibility and proneness to yield sediment is still lacking.

Researches on Watershed Management

18.7.5 The urgent need of collecting accurate basic information about watersheds by setting up the requisite number of 'A' class benchmark stations and a larger number of 'B' and 'C' class stations spread over the entire country has been emphasised earlier. The application of the data so obtained for interpreting quantitatively the future behaviour of the reservoir is determined by the exactness of the functional relationship between the factors involved. Owing to lack of relevant research work in India, workers in this country have so long depended upon research information from other countries which are not necessarily similar in agroclimatic and other conditions. As a result, considerable amount of empiricism has been allowed. Experience shows that in the case of watershed management, the borrowing of research results may have drastic consequences. It is essential, therefore, to have indigenous research set up for investigating the quantitative aspects of watershed management under conditions prevailing in the catchments of the river valley projects. A similar observation has been made by the Sub-committee on Watershed Management of the National Committee on Science and Technology (NCST) which has programmes of research to fill up gaps in basic knowledge.

Land Resource Regions

18.7.6 No systematic work has so far been done to prepare an inventory of land resources and the problem areas in the country.

The Soil and Water Conservation Research and Training Institute of Dehra Dun has made an attempt to collect available data and prepare a map showing land resource regions which have been classified on the basis of soil, climate and present land use. These land resource regions have been sub-classified as resource areas based on rainfall, present land use, command areas of major, medium and minor irrigation projects and rainfed lands. The interpretation and classification of land resource areas thus made are based on scattered published information, local experience and research results. There is, therefore, need for initiating further work in a scientific manner and to make an organised attempt to collect relevant data systematically to help better differentiation of the land resource regions. In course of standard soil surveys comprehensive data on soils including geology, land slope, drainage conditions, climate, erosion, land use, crops and farming history, irrigation sources, population and socio-economic conditions are collected. The Directorate of All-India Soil and Land Use Survey may, therefore, be charged with the responsibility of preparing an inventory of land and soil resources of the country, assess the nature and extent of soil and moisture conservation problems, classify the country into different land resource regions and areas and map them on a suitable scale.

Conservation Hydrology

18.7.7 Studies have been in progress at various research stations on conservation hydrology which utilises data on such factors as precipitation, infiltration, evapotranspiration and surface runoff. Total precipitation and its intensity are available from ordinary and recording rain gauges. Precipitation data are being used in the Dehra Dun, Ootacamund and Agra Centres to work out values of recurrence interval and rainfall erosion-indices and also to study effect of climatic associates on crop growth. In view of the need for data on frequency distribution of rainfall, effective rainfall and other climatic parameters, it would be necessary to take up collection of all pertinent data from the India Meteorological Department (IMD) and other stations recognised by IMD in the country. The data on the above aspects are required for design of various erosion control structures. Some work of a limited nature has been done on infiltration at Ootacamund and Dehra Dun Centres. The collection of data on infiltration under different soil and cover conditions would be necessary to work out hydrographs under natural rainfall conditions, estimate moisture storage in the soil and compute rainfall erosion indices. It would, therefore, be necessary to intensify study on infiltration and cumulative moisture intake at all research centres and collect data as detailed above.

Observations on surface runoff from standard-size plots under different covers and cultural practices are being recorded in the various soil conservation research centres (*vide* paragraph 18.7.12).

Conservation Agronomy

18.7.8 Researches have been in progress in various soil conservation research centres on different aspects of conservation agronomy, namely, (a) effect of various crops on runoff and soil loss, (b) selection of suitable crops to provide effective canopy and mulching, (c) tillage and cultural practices, and (d) physical properties of soils. Soil conservation, in general, aims at maintaining the soil at the optimum level of productivity on sustained basis. The problems of research need encompass all aspects of soil and moisture conservation both in irrigated and rainfed lands. There are still gaps in knowledge on the maintenance of soil productivity at optimum level even though some work has already been done. Research efforts on conservation agronomy should be further strengthened by including such studies as (a) selection of crops, cropping systems, geometry of cropping, crop rotations, mixed cropping, intercropping and strip cropping with reference to rooting habits of crops; (b) tillage practices to optimise soil moisture regime in the root zone; (c) crop response at different stages of growth under various moisture levels; and (d) development of proper water harvesting and water recycling techniques for rainfed agriculture.

Erosion Control Structures

18.7.9 The primary and immediate objective of soil and moisture conservation should be to stop the movement of soil so that what little soil is left on the land is retained for proper utilisation. This is achieved by construction of properly designed erosion control structures. Some good work has been done on mechanical measures in all the research centres. The studies made so far cover contour farming, bunding, terracing, drop structures, earthen dams and ponds. Yet many more measures for mechanical manipulation would provide scope for better conservation by way of improving the techniques and specifications. We would like to draw particular attention to the lack of researches on mechanical measures applicable to deep black cotton soils for which no satisfactory solution has yet been found. Soil conservation research is a continuing process to help develop better and more efficient measures. Studies on such measures with special reference to conservation structures, such as contour and graded terracing, bench terracing, grassed waterways and diversions should be

augmented. Better criteria for design of bunds, earthen dams and other soil conservation structures should be developed. Studies should also be initiated on parallel terracing and zigzag terracing with a view to avoiding point rows and sharp turns for various agricultural operations using tractors.

Conservation Forestry

18.7.10 Experiments conducted in all the research centres cover the major aspects of conservation forestry such as plant introduction, growth studies, forest influence to intercept rainfall, runoff studies and afforestation technique and grassland management. Studies have been designed mainly to provide guidance for reclothing the denuded areas and improving the grassland both for protection of land against erosion hazards and advising on proper and economic utilisation of land not capable of sustaining agriculture. Studies relating to soil conservation forestry should be diversified and intensified (cf. Chapter 42 on Production and Soil Forestry). The available knowledge required to improve extensive grazing lands and maintaining grass reserves is not adequate. Suitable investigations should be undertaken to fill up the gap.

Gully Erosion

18.7.11 Vast areas of land along the banks of the rivers in Gujarat, namely, the Banas, the Sabarmati, etc. are affected by severe gully erosion. It is estimated (*vide* Chapter 17 on Land Reclamation and Development) that 0.4 million hectares of land have been converted into ravines. In Rajasthan and Madhya Pradesh, the ravine problem is serious on the banks of the river Chambal and similarly in Uttar Pradesh on the banks of the Yamuna. In ravine reclamation work, proper emphasis has to be laid on the treatment and protection of agriculturally productive tablelands and stabilisation of marginal lands and gully heads. Roads and railways not only cause erosion but also impede drainage and create problems of waterlogging and salinity. Stream bank erosion, land slips, etc. contribute to sediment load. Studies on ravine control and reclamation are in progress at Agra, Kota and Vasad. Studies on torrent control, landslides and ravine control, especially in hilly regions, should be initiated with the ultimate objective of (a) classifying, controlling and reclaiming gullies; and (b) evolving package of practices to control roadside and railside erosion and techniques of stabilisation of problem areas, such as those frequently affected by landslides and hill torrents. Earlier in this Section reference has been made to the hazards of shifting cultivation in the hilly

areas of Eastern India. These problem areas are not provided with facilities for systematic study. Extensive studies on problems of the above mentioned hazardous land use should be undertaken so that further deterioration of land resource could be adequately prevented.

Universal Soil Loss Equation

18.7.12 Attempts have been made to collect data on soil loss from standard plots and also from field size plots to evaluate various factors such as erosion index (R), soil erodibility factor (K), crop management factor (C), degree and length of slope factor (S), and erosion control practices factor (P) of the following universal soil loss equation :

$$A = R \times K \times C \times S \times P$$

where A is the annual soil loss in terms of tonnes per hectare. The studies so far made indicate the need for working out the crop management factor for different crop rotation practices recommended for various regions.

Training

18.7.13 The technical services for the execution of soil and moisture conservation measures have to be provided by adequately trained personnel. The training is intended to develop a broad understanding of soil and moisture conservation and of the interrelationship of disciplines like soil science, agronomy, forestry, range management, wildlife etc. in the conservation programme. The training should also provide the study of principles of human relationship because implementation of conservation measures requires understanding of social attitude towards such measures. There is great scope for an interdisciplinary approach in matters relating to watershed management. The vastness of the country and its varied land and climatic situations bring diversity into its conservation problems. The trainees should, therefore, be so equipped as to address themselves to varied kinds of problems and situations.

Training Centres

18.7.14 A regular training programme in soil and moisture conservation for gazetted officers was initiated during the First Five Year Plan at the Soil Conservation Research Centre at Dehra Dun, and for assistants at Ootacamund, Bellary, Kota and Hazaribagh. About 2,750 persons have been trained in these two centres upto the end of 1973. Out of these, 813 have been officers and the remaining were graduate

assistants. It has been estimated by the ICAR that a total of 3,700 graduates and postgraduates trained in the fields of agricultural engineering, soil science, agronomy, forestry, hydrology, sedimentation, etc. would be required till the end of the Fourth Five Year Plan alone for executing soil and moisture conservation programmes in the different areas, including those under cultivation and catchments of river valley projects. The requirement of field assistants and subassistants for the Fourth Plan has been estimated by ICAR at 16,100. During the Fifth Plan the requirement would be nearly doubled. In view of the large gap in the requirement and availability of trained personnel, it would be necessary to strengthen the training facilities at various soil conservation research and training centres. The training of officers and of graduate assistants may be imparted at the Soil and Water Conservation Research and Training Institute and its substations. The inservice training of the field assistants and subassistants may be imparted by the soil conservation organisations existing in different states. This programme should receive a high priority.

Role of Agricultural Universities

18.7.15 Because of the great significance of soil and moisture conservation in resource preservation and utilisation, it becomes imperative to gradually develop expertise in the field by way of education and research. Agricultural Universities may play a suitable role in this regard. As has been discussed earlier, the land users have to be involved in the programme. It is desirable to educate them on the principles and benefits of soil and moisture conservation for which the krishi vigyan kendras will be eminently suitable.

Publication of Manuals

18.7.16 In order to provide guidance to the technicians in the matter of collection and compilation of technical data, designs of various conservation structures, investigation and execution of various programmes of work and for understanding soil and drainage conditions, manuals or technical guides and handbooks are a great necessity. These manuals should incorporate proven research data and recommendations emanating therefrom for adoption in the field. The ICAR should be entrusted with the task of preparing a model manual for the benefit of the State Governments. Afforestation being an important aspect of soil conservation, the collaboration of the Forest Research Institute may be sought in the preparation of the manual. The task of preparing manuals based on the ICAR model, which would be necessary for execution of soil conservation programmes in the states should be

entrusted to the respective State Governments. The regional centres which are to help the State Governments in planning and designing soil conservation measures should periodically review these manuals and make them up to date.

Priorities in Training and Research

18.7.17 The strengthening of the existing research projects and the opening up of new projects as recommended would provide employment opportunities for approximately 200 technical, 175 nontechnical and 400 unskilled personnel per year during the Fifth Five Year Plan period. The number is bound to increase during the Sixth and subsequent five year plan periods. It is considered necessary to attach certain priority in the execution and implementation of recommendations regarding the aforesaid programmes. The following priorities (not yearwise) are suggested :

Priority I: affording training facilities after ascertaining requirement of personnel from the State Governments;

Priority II: strengthening research (both basic and applied) at the existing research stations to fill up the gaps in knowledge pointed out earlier;

Priority III: opening additional research stations;

Priority IV: starting comprehensive pilot watershed studies.

It has been estimated that during the Fifth Plan the financial requirement would be of the order of Rs. 3-4 crores for the purpose of research and training. As the work expands in subsequent plans, larger amounts would be required. Thus, during the Sixth Plan, the financial requirement may be of the order of Rs. 10 crores.

18.7.18 In paragraph 18.4.9 mention has been made of the fact that only about one-third of the discharge observation sites are being used for collection of silt data. This is mainly due to lack of trained personnel, proper equipments and laboratory facilities. As a result, the quality of data is below standard. In view of the trend of overall development of water resources, a number of new gauging sites having a certain percentage of sophisticated equipments have to be set-up at selected locations. All these would require additional trained personnel of the right quality. It has been estimated by the CWC that for the next five years alone about 2000 trained personnel would be required.

8 SUMMARY OF RECOMMENDATIONS

18.8.1 The following is a summary of the important recommendations made in this chapter.

1. In view of hazards of rapid siltation of rivers and streams, a firm strategy for tackling the conservation works in the watersheds of river valley projects should be planned quickly, preferably within five years.

(Paragraph 18.2.7)

2. In conformity with the international standard, a soil map of India in the scale of 1 : 1 million is considered necessary and adequate. The comprehensive system of soil classification developed by the United States Department of Agriculture (USDA) should be suitably modified, where necessary, and adopted and brought in line with the international system of soil classification as adopted by Food and Agricultural Organisation. Expeditious measures should be taken to prepare the soil map of India in 1 : 1 million scale and to organise additional 170 soil survey parties in accordance with the specific requirements of the States and the Centre. Aerial photographs, at least for the nonsensitive areas, should be made available for accelerating soil survey work. The Directorate of All India Soil and Land Use Survey which is charged with the training of soil survey personnel and soil correlation and classification at the national level, should be appropriately strengthened. An integrated training course in collaboration with the Indian Photo Interpretation Institute of the Survey of India should be organised. The State soil survey organisations should be strengthened with properly trained personnel in order to carry out all new surveys as well as resurveys on the standard pattern. A close liaison between the Central and State soil survey organisations is imperative. For this purpose, the State coordination committees, wherever formed, should be activised and wherever not yet formed, should be constituted as early as possible. State coordination committees should utilise the existing data on soil survey for land use and crop planning after due interpretation.

(Paragraph 18.5.2)

3. The programme of soil survey should include hydrological and erodibility groupings of recognised soils in order that soils producing sediment get quickly identified. Soil and land use survey should precede soil conservation measures, so that the latter can be based on the recommendations of the former. Gaps noticed in the progress of either should be expeditiously bridged.

(Paragraph 18.5.3)

4. In view of the irreparable damage done to reservoirs, by siltation, high priority should be attached to the treatment of those lands in the watershed which deliver the largest amount of sediment to the reservoirs.

(Paragraph 18.5.4)

5. A time-bound programme needs to be drawn up for the aerial

survey of the remaining catchment area and for correlation with sediment inflow and its transport via rivers and streams and delivery into reservoirs. This would help better identification of priorities for treatment.

(Paragraph 18.5.4)

6. The inadequacy of rainfall data in the watersheds of the various river valley projects calls for the following urgent measures :

(i) the location of all raingauges should be fixed if necessary by a special scheme within two years;

(ii) all nonstandard raingauges should be replaced by standard ones;

(iii) IMD's plan for installation of 1200 additional raingauges on the basis of WMO's recommendations should be re-examined;

(iv) a special unit should be established in the IMD with powers and responsibilities and suitable financial assistance to instal additional network of raingauges, and collect and publish all available data within a period of 3 years;

(v) correction factors applicable to all the defective raingauges should be determined as early as possible; and

(vi) a minimum network of self-recording raingauges as would enable publication of maps of short duration rainfall and frequencies within a period of 10 years should be established.

(Paragraph 18.5.6)

7. Conservation measures in catchment areas should have the same priority as the development of command areas.

(Paragraph 18.5.8)

8. Due consideration should be given to the physical and morphological characteristics of soils in the development of precise techniques for soil and moisture conservation.

(Paragraph 18.5.10)

9. Alternating grass and crop varieties is an important measure of soil conservation and moisture preservation. In the multiple cropping programmes grasses should find a place.

(Paragraph 18.5.14)

10. Private degenerated lands which may be the foci of erosion should be treated for purposes of conservation, e.g., for farm forestry with technical help from the forest department; or else the State Government should notify the owners of such lands for including them in land development schemes.

(Paragraph 18.5.16)

11. Instead of treating soil conservation in catchment areas as one of saving life of reservoir, it should be looked at as part of program-

mes for maximising land use. To attain this end, all related programmes should be drawn up in a coordinated manner.

(Paragraph 18.5.18)

12. Considering the limited forest area available in the catchment areas, every bit of degraded forest land should be replanted with intensified efforts. According to suitability and feasibility, a programme of either farm forestry or commercial forestry should cover a substantial portion of the catchment areas.

(Paragraph 18.5.19)

13. Grass reserves should be created in forest areas and community lands. This would link up soil and moisture conservation of degraded areas in the catchment with programme of milk production and make both of them economical ventures.

(Paragraph 18.5.20)

14. Areas showing reasonable rise in productivity as a result of conservation measures should be identified in catchment areas and an institutional programme of credit should be developed, so that farmers would find it profitable to take up soil conservation work. This step would substantially minimise direct investment by State Governments for the overall soil conservation work.

(Paragraph 18.5.21)

15. In soil and moisture conservation works covering wide areas in the watersheds and involving a large number of people, extensive participation of the people at the district, block and village levels would ensure superior performance and higher achievements, particularly in respect of the maintenance programme.

(Paragraph 18.5.22)

16. All storages with a hypothetical limit of 12.5 thousand ham and above should be treated as having inter-state implications. In such a situation the Centre should provide financial and supervisory assistance for the watershed management. Since the benefit accrues directly to the States in various ways, such projects should be financed by the Centre and the States concerned.

(Paragraph 18.5.23)

17. The work of gauging silt and discharge of various rivers and their tributaries should be a Central responsibility. Adequate funds should be provided for the purpose.

(Paragraph 18.5.24)

18. Particulars of watersheds should be continually collected and systematically studied in order to take corrective measures. For river valley projects, the catchments of which are situated in more than one State, the data should be collected by the Ministry of Agriculture and Irrigation with the assistance of the concerned States, ana-

lysed and stored in one place for the benefit of users.

(Paragraph 18.5.25)

19. The location of gauging stations should be planned carefully to cover all major situations. In view of the urgency and importance of sediment data, it should be made obligatory on the part of all the discharge observation sites to obtain sediment data as well. At least 10 per cent of the observation units should be run by the central agency and classed as 'A' class stations after having been provided with sophisticated equipment and standard arrangements for observations and checks.

(Paragraph 18.5.26)

20. Watershed management should be initiated well in advance, preferably before the execution of the project itself. Advance action results in stabilisation of the watershed thereby putting the water resource development project on a firm basis. Priority determination should be based on sediment yield and experience in similar catchment areas.

(Paragraph 18.5.27)

21. At present the water resources projects are handled by one organisation, whereas watershed management projects are handled by another. The two are so intimately related that whenever a water resource development project is planned, the authority responsible for watershed management should be simultaneously associated with it, so that both works run complementarily and parallelly.

(Paragraph 18.5.28)

22. For comprehensive planning and effective execution of soil conservation programmes, the organisation should be adequately strengthened so as to meet the requirements of a coordinated programme of conservation, use and management of soil and water.

(Paragraph 18.6.1)

23. The jurisdiction of an Assistant Soil Conservation Officer should be fixed and he should be required not only to tackle fresh problem areas but also to maintain the areas already treated. An area treated once can be taken up for fresh treatment after 5—7 years depending on the condition of deterioration.

(Paragraph 18.6.2)

24. An inter-directorate committee presided over by the Agriculture Production Commissioner may take up soil conservation on a coordinated basis and as a special action programme.

(Paragraph 18.6.3)

25. The amount due from each landholder as cost of soil conservation works in cultivated lands should be recovered in suitable instalments depending on the nature of operations and cost involved. The number

of instalments may be made conveniently larger in case of small and marginal farmers. In course of time this concession should apply to marginal farmers only.

(Paragraph 18.6.5)

26. For lands suitable for afforestation and grass production the forest department should suitably include them in their programmes of afforestation and conservation and realise part of the expenditure from the sale of either forest produce or grasses.

(Paragraph 18.6.5.)

27. Indigenous research setup is essential for investing the quantitative aspects of watershed management under conditions prevailing in the catchments of the river valley projects in India.

(Paragraph 18.7.5)

28. A scientific appraisal of the land and soil resources should be made by the Directorate of All India Soil and Land Use Survey to enable preparation of an inventory of the above resources, assess the nature and extent of soil and moisture conservation problems in the country, classify the country into different land resource regions and subregions and map them on a suitable scale.

(Paragraph 18.7.6)

29. Studies on conservation hydrology already being conducted at various research centres should be intensified so as to include the following aspects: (a) watershed hydrology with special reference to precipitation, frequency distribution etc; (b) rainfall erosion indices; and (c) infiltration rates and cumulative intake for different hydrological soil units.

(Paragraph 18.7.7)

30. Research work on conservation agronomy should be strengthened to include the following aspects: (a) selection of crops, cropping systems, geometry of cropping, crop rotations, mixed cropping, intercropping and strip cropping with reference to rooting habits of crops; (b) tillage practices to optimise soil moisture regime in the root zone; (c) crop response at different stages of growth under various moisture levels; and (d) development of proper water harvesting and water recycling techniques for rainfed agriculture.

(Paragraph 18.7.8)

31. Studies on mechanical measures with reference to conservation structures, such as contour and graded terracing, bench terracing, grassed waterways and diversions should be augmented. Criteria for design of bunds, earthen dams and other soil conservation structures should be developed. Studies should be initiated on parallel terracing and zigzag terracing with a view to avoiding point rows and sharp turns for various agricultural operations using tractors.

(Paragraph 18.7.9)

32. The gap in available knowledge for improving extensive grazing land and maintaining grass reserves should be filled up.

(Paragraph 18.7.10)

33. Studies on torrent control, landslides and ravine control, especially in hilly regions, should be initiated with the ultimate objective of (a) classifying, controlling and reclaiming gullies; and (b) evolving package of practices to control roadside and railside erosion and techniques of stabilisation of problem areas, such as those frequently affected by landslides and hill torrents. Extensive studies on the problems of shifting cultivation and consequent hazards and steps to prevent them should be undertaken.

(Paragraph 18.7.11)

34. Priority should be given to studies aimed at evaluating the various factors in the universal soil loss equation, particularly for the adopted crop rotations.

(Paragraph 18.7.12)

35. In view of the large gap in the requirement and availability of trained personnel, the training facilities at the various soil conservation research and training centres should be strengthened. The training of officers and of graduate assistants may be imparted at the Soil and Water Conservation Research and Training Institute and its substations. The inservice training of the field assistants and sub-assistants may be imparted by the soil conservation organisations existing in different States. This programme should receive a high priority.

(Paragraph 18.7.14)

36. Agricultural universities should gradually build up expertise in the field of research and education on soil and moisture conservation. The krishi vigyan kendra would be eminently suitable to educate the farmers on the principles and benefits of soil and moisture conservation.

(Paragraph 18.7.15)

37. Suitable action should be taken to bring out manuals and handbooks incorporating research data and recommendations emanating therefrom for adoption in the field. The ICAR should be entrusted with the task of preparation and publication of such manuals for the benefit of the State Governments. Afforestation being an important aspect of soil conservation, the collaboration of Forest Research Institute may be sought in the preparation of the manual. The task of preparing field manuals necessary for the execution of soil conservation programmes in the States should be entrusted to the respective State Governments. The regional centres which are to help the State Governments in planning and designing soil conser-

vation measures should periodically review these manuals and make them up to date.

(Paragraph 18.7.16)

38. Certain priorities should be assigned in the implementation of recommendations regarding training and research in soil and water conservation. The following priorities (not yearwise) are suggested :

Priority I: affording training facilities after ascertaining requirement of personnel from the State Governments.

Priority II: strengthening research (both basic and applied) at the existing research stations to fill up the gaps in knowledge pointed out above.

Priority III: opening additional research stations.

Priority IV : starting comprehensive pilot watershed studies.

(Paragraph 18.7.17)

APPENDIX 18.1

(Paragraphs 18.2.1 & 18.2.2)

Classification of Area[1] —1970-71*

	Area (thousand hectares)	Percentage of total reporting area	Percentage of total geographical area
1	2	3	4
1. Area under forest	65,978	21.6	20.1
2. Area not available for cultivation	45,368	14.8	13.8
(i) area under non-agricultural uses	16,218	5.3	4.9
(ii) barren & unculturable land	29,150	9.5	8.9
3. Other uncultivated land excluding fallow land	33,781	11.1	10.3
(i) Permanent pastures and other grazing land	13,314	4.4	4.1
(ii) Land under Misc. tree crops and groves not included in net area sown	4,366	1.4	1.3
(iii) Culturable waste	16,101	5.3	4.9
4. Fallow land	19,745	6.5	6.0
(i) Other than current fallows	8,612	2.8	2.6
(ii) Current fallows	11,133	3.7	3.4
5. Net area sown	140,398	46.0	42.8
6. Total reporting area	305,270	100.0	93.0
7. Total geographical area	328,048		100.0

* Provisional.

1 1975 Indian Agriculture in Brief, Fourteenth Edition. Directorate of Economics & Statistics, Ministry of Agriculture and Irrigation, Government of India, New Delhi.

APPENDIX 18.2

(Paragraph 18.2.1)

Statewise Classification of Area (1970-71)[1] Together With Area under Minor Forests

('000 hectares)

State/Union Territory	Reporting area	Forests	Net area sown	Forest area as percentage of reporting area	Area under minor forests**
1	2	3	4	5	6
Andhra Pradesh	27,440	6,337	11,735	23.1	1450
Assam	7,795(a)	2,080(a)	2,235	26.7	83
Bihar	17,330	2,928	8,454	16.9	1300
Gujarat	18,562(a)	1,634(a)	9,220(b)	8.8	724
Haryana	4,402	99	3,565	2.2	8
Himachal Pradesh	5,076	2,782(c)	546	54.8	..
Jammu & Kashmir	4,523(d)	,776(c)	706	61.4	..
Karnataka	18,943	2,890	10,248	15.3	..
Kerala	3,859	1,055	2,172	27.3	N.A.
Madhya Pradesh	44,238	14,459	18,352	32.7	4400
Maharashtra	30,758	5,417	17,668	17.6	2054
Manipur (e)	2,211	602	140	27.2	78
Meghalaya (f)	2,249(a)	187(a)	162	8.3	..
Nagaland (g)	1,351	266	60	19.7	Nil
Orissa	15,540	4,973	6,119	32.0	1295
Punjab	5,031	123	4,053	2.4	Nil
Rajasthan	34,109	1,355	15,179	4.0	N.A.
Tamil Nadu	13,004	2,013	6,169	15.5	381
Tripura	1,048	630	240	60.1	259

1 Directorate of Economics & Statistics, Ministry of Agriculture and Irrigation, Government of India.

(a) relates to the year 1969-70.

(b) estimated.

(c) includes forest area under control of Forest Department also.

(d) excludes information for areas under unlawful occupation of China & Pakistan.

(e) ad-hoc estimates.

(f) relates to Garo Hills and U.K. & J. Hills districts of Assam.

(g) relates to Naga Hills district of Assam State for the year 1956-57.

** NCA Interim Report on Production Forestry — Man-made Forests.

APPENDIX 18.2 (*Contd.*)

1	2	3	4	5	6
Uttar Pradesh . . .	29,806	4,952	17,305	16.6	N.A.
West Bengal (h) . .	8,852	1,101	5,633	12.4	445
Union Territories . .	9,143	7,319	437	80.1	14
Total All India . .	305,270	65,978	140,398	21.6	12,491

(h) relates to the year 1967-68.

APPENDIX 18.3

(Paragraph 18.2.7 & 9)

Sediment Data of Selected Reservoirs[1]

Reservoir	Year of impounding	Net catch-ment area in sq km	Capacity in Mham		Total sediment deposited	
			gross	dead	ham	period upto
1	2	3	4	5	6	7
Bhakra Nangal	1959	56,876	0.934	0.205	52,821	1974
Hirakud	1956	82,652	0.814	0.232	44,512	1971
Tilaiya	1953	984	0.039	0.007	..	..
Maithon	1956	5,206	0.136	0.002	10,962	1971
Panchet	1956	9,816	0.150	0.018	17,663	1974
Konar	1955	998	0.034	0.006	..	..
Machkund	1956	1,956	0.072	0.001	658	1970
Tungabhadra	1953	25,832	0.377	0.007	32,336	1972
Mayurakshi*	1955	1,792	0.061	0.007	4,710	1970
Gandhisagar dam	1960	21,873	0.651	0.083	7,214	1970
Ramganga	1974	2,997	0.230	0.025	7,727	1971
Kangsabati	1965	..	0.114	0.015	862	1970
Ghod	1966	3,629	0.022	0.007	2,765	1970
Dhantiwad	1965	2,862	0.046	0.008	646	1968

Annual average rate of silting in ham	Annual rate of silting in ham per 100 sq km		Corrected after conversion of suspended data to deposited data ham/100 sq km	Remarks
	assumed	observed		
8	9	10	11	12
3,521	4.29	6.14	6.14	capacity survey is being repeated every year
2,968	2.52	3.58	6.28	inflow-outflow method
..	5.09	..	..	capacity survey not done
685	1.62	13.10	13.10	capacity survey done in 1963, 1965 and 1971
978	2.47	10.00	10.00	capacity survey done in 1962, 1964, 1966 and 1974
..	2.76	..	..	capacity survey not undertaken
51	3.90	2.57	3.57	inflow-outflow method
1,702	4.29	6.54	6.54	capacity survey done in 1963, 1972
294	3.61	16.43	16.43	capacity survey done in 1965 and 1970
811	3.61	3.71	6.02	inflow-outflow method
546	4.29	18.19	18.19	sediment inflow data
142	3.27	3.76	9.65	Do.
553	3.61	15.24	15.24	inflow-outflow method
130	3.61	4.52	5.95	Do.

APPENDIX 18.3 (*Contd.*)

Sediment Data of Selected Reservoirs (*Concld.*)

1	2	3	4	5	6	7
Beas unit II	1974	6,825	0.811	0.130	8,881	1968
Lower bhawani	1953	4,201	0.093	0.002	2,102	1965
Matatilla	1958	20,604	0.113	0.035	7,260	1969
Nizamsagar**	1931	18,524	0.084	0.012	43,635	1967
Ukai	1971	62,225	0.839	0.142	83,181	1969
Narmada	under construction	87,516	0.681	0.422	44,734	1970
Tawa***	1974	5,983	0.231	0.022	5,300	1973
Mahi stage II	under construction	25,330	0.170	0.039	..	1973
Sivajisagar++	1961	777	0.299	..	594	1971

* the sediment rate for the period 1965—70 (five years) is 22.77 ham/100 sq km/year.

** the sediment rate during five years (1962—66) is 12.76 ham/100 sq km/year.

*** silt data pertain to the period from 1958—70 (col. 4 — gross area of the catchment, reservoir area) (col. 7 — total sediment deposited from the year of impounding upto the year of observation).

++ impounded in 1961 but loss of capacity reckoned from 1966.

NA—not available.

1—latest data obtained from soil conservation directorate, central water commission, Min. of Agriculture & Irrigation, Faridabad.

8	9	10	11	12
987	4.29	14.29	14.29	sediment inflow data
176	N.A.	4.19	4.19	capacity survey done in 1965
919	1.43	4.00	4.00	capacity survey
1,214	0.29	6.55	6.55	last capacity survey done in 1967
6,848	1.47	10.95	14.29	inflow-outflow method
4,959	1.55	5.62	9.52	inflow-outflow method
670	3.61	11.15	15.60	sediment inflow data
691	1.29	2.72	6.61	Do.
119	..	15.24	15.24	capacity survey done in 1966 and 1971

APPENDIX

Progress of Soil Conservation Works in Different States and

State	Present status of soil and land use survey	Present position regarding demarcation of state into Agroclimatic zones	Nature and extent of soil conservation works carried out
1	2	3	4
Andhra Pradesh	soil survey and land capability classification not carried out; soil surveys of the commanded areas of major river valley projects have been taken upto demarcate areas suitable for various intensities of irrigation.	based on annual rainfall, Andhra Pradesh has been divided into 3 regions :— (i) north coastal Andhra and northern Telengana with average annual precipitation of 906 mm; (ii) mid Telengana and south coastal Andhra with average annual precipitation of 760 to 906 mm; (iii) Rayalseema, Mahboobnagar and Nalgonda districts with average annual rainfall below 760 mm. broadly (a) coastal Andhra, (b) Rayalseema, and (c) Telengana	main emphasis on contour bunding with stone terracing; and bench terracing gully plugs and check dams also constructed; area brought under soil conservation measures upto the end of March, 1971. 3,38,000 hectares.

18.4

(Paragraph 18.4.8)

Other Related Aspects. (Summary of Replies to Questionnaire)

Soil conservation measures—types, specification, techniques, etc. as per the requirements of Agroclimatic zones	Benefits of soil conservation measures	Procedure adopted in the assessment of benefits	Land shaping
5	6	7	8
(i) contour bunds, stone terracing and bench terracing in shallow and wide gullies (in low rainfall areas, i.e. less than 75 cm)	bunding had resulted in increased yield of crops; in crop cutting experiments during 1961—63 on red soils, percentage increase in the yield of kharif jowar was 8 to 70, bajra 26, groundnut 11 to 63, castor 4 to 66, red gram 11 to 33. On black soil the percentage increase for jowar was 12 to 100.	—	—
(ii) *upto* 10% *slope bunding :* graded bunds, stone bunds and E.T. in shallow and wide gullies (rainfall 30" or 75 cm and above); (iii) 10 *to* 33% *slope bunding :* stone terracing and bench terracing (rarely soil conservation works are taken in slopes above 15%); (iv) *Other areas :* tree planting and afforestation. The cross section of 4 sft. with 2′ height 1′ top width and 3′ bottom width in heavy rainfall areas and 3′ section in low rainfall areas are prescribed.	considerable replenishment of the underground water table as a result of bunding also took place.		

APPENDIX

1	2	3	4
Assam	no systematic soil survey has been undertaken; soil characteristics are, however, taken into account while selecting areas for conservation works, e.g. terracing, afforestation or cash crop cultivation.	on the basis of soil and topography, the state is divided into 3 regions : (i) mikir hills and north cachar hills; (ii) undulating and gently sloping tracts on north bank of brahmaputra; (iii) alluvial flat land on south bank of brahmaputra.	*in areas now falling in the newly formed States of Meghalaya and Mizoram :* terracing of gently sloping land, reclamation of valley bottom land lying idle and bunding; introduction and extension of perennial cash crops on steep slopes and afforestation of steep and eroded lands. *north bank of brahmaputra :* provision of masonry bamboo and brushwood check dams, periphery bunds, diversion channels and contour bunding, afforestation and construction of spurs. progress upto 1971 : gully control structure=300 Nos. area protected= 7,200 hectares afforestation=9,980 hectares.
Gujarat	soil survey and land capability classification are in progress since 1967 in IADP areas of Surat and Bulsar districts. Some problem areas, government farms and research stations have also been surveyed in detail, the area so surveyed is 78,649 hectares.	on the basis of climate, soil type and cropping pattern, 8 zones have been differentiated as follows : *areas receiving rainfall* 1. more than 1500 mm 2. 1000—1580 mm 3. 800—1000 mm 4. 625—825 mm 5. 625—1000 mm 6. 625—750 mm 7. 480—700 mm 8. 250—500 mm	contour bunding in rainfed zones (0.1 million hectares), terracing and nallah plugging works in hilly areas, ravine reclamation along the rivers Mahi, Sabarmati, Shatrunji (2000 hectares) and field channels (40,000 hectares) in the command areas. area covered= 1,42,800 hectares.

18.4 (*Contd.*)

5	6	7	8
details not given.	benefits of soil conservation works were as follows : (i) in the regions on the north bank of brahmaputra actual physical protection to land which otherwise would have turned into gullies, and (ii) increase in paddy yield of about 50 per cent.	data furnished by the beneficiaries.	land shaping work done in the hill districts; most of the land shaping work is in the form of bench terraces.
contour bunding in the land having 5 to 6 per cent slope in the dry areas; nallah plugging and terracing works in the hilly areas where sufficient depth of soil is available and the per cent of slope is more than 6 per cent; kotar reclamation work is carried out in the ravine areas.	bunding increased the yield of jowar to the extent of 51 per cent and of wheat 13 per cent; similarly, groundnut and hybrid maize showed increases in yields of 15 per cent and of 7 per cent respectively.	crop cutting experiments in Panchmahals and Kutch districts as per model scheme prescribed by IARI.	done in command areas of irrigation projects mostly by cultivators.

APPENDIX

1	2	3	4
Himachal Pradesh	soil survey and land capability classification are conducted as prerequisite for soil conservation works mostly on village basis.	four major agro-climatic zones as follows : 1. low hills 2. mid hills 3. high hills 4. dry zones.	soil conservation work concentrated in the catchment areas of Sutlej and Beas rivers, very little work done in high hills and dry zones; area treated to end of March, 1971 is 8,000 hectares.

18.4 (*Contd.*)

5	6	7	8
slope class decides the type of the measure to be adopted.	—	—	work being done by bull-dozers at Sundernagar, Una and Bilaspur; work recently started.
class	*slope range*	*measures applicable*	*techniques adopted*
I (valley areas of low hill zone)	0—10%	(i) levelling (ii) graded contour bunding	levelling with manual labour; aligned along falling contour; longitudinal grade of 1 in 120 is maintained; soil excavated on the lower side of the bund.
II (rest of the areas)	10—40%	inward sloping, bench terracing	inward sloping bench terraces constructed at a convenient vertical interval ranging from 2′ to 6′ depending upon the slope and soil depth. A longitudinal grade of 1 in 120 is maintained. Inward slope of the terrace is 1 in 15 to 1 in 20; excavation of soil filled in the lower half of the terrace; outlet for excess rainwater provided.
III (rest of the areas)	40—60%	contour strips for the plantation of fruit trees	contour strips: a 4′ strip along with the contour by providing a convenient vertical interval ranging from 6′ to 12′ used only to plant fruit trees or orchards.

APPENDIX

1	2	3	4
Kerala	soil survey and land capability classification is carried out on specified standards; detailed soil survey has been completed in Trivandrum district, Calicut taluka, commanded areas of pamba and kuttiyadi irrigation projects and the district agricultural farms; survey is in progress in command areas of kallad and pazhassi projects and selected watersheds; to undertake such surveys in other irrigation projects is under proposal.	The state has not been demarcated into agro-climatic zones.	contour bunding, terracing, etc. done in the State; reclamation of water-logged and khar lands is also taken up by constructing ring bunds and pumping out water; area covered 41,600 hectares.
Madhya Pradesh	detailed and reconnaissance soil surveys are in progress in command areas or irrigation projects and the seed multiplication farms, areas covered by surveying so far is 5.5 lakh hectares.	fourteen zones demarcated on the basis of climate, crops and problems of production as follows : 1. malwa plateau 2. vindhyan plateau 3. kymore plateau 4. satpura plateau 5. pastar plateau 6. nimer plains 7. upper narmada valley 8. wainganga valley 9. chambal valley 10. mahanadi plains 11. bundelkhand region 12. jhalam hills 13. western satpura hills region 14. eastern satpura hills region.	contour bunding (17,67,000 hectares) and ravine reclamation (130 hectares) works carried out upto December 1971; in the catchment areas of the river valley project, contour bunding, terracing, afforestation, grass land development, nallah bunding silt arresting dams and other engineering measures adopted. area covered = 1,61,460 hectares.

18.4 (*Contd.*)

5	6	7	8
soil conservation schemes, taken up by soil conservation department in accordance with the provisions of the K.L.D. Act 17 of 1964 and Rules thereunder. different vertical intervals followed in different slope percentage in general are : 1.5 to 2 mtrs. in lands having slopes upto 15% 3 mtrs. in lands having slopes upto 35% and 5 mtrs, in lands having slopes above 35% contour bunds and terraces with dry rubbles gravels or laterite, pitched walls are constructed. earthen bunds constructed where enough stones, rubble, etc. are not available.	—	—	very few beneficiaries have undertaken land shaping work in the hilly agricultural lands where contour terracing work was done departmentally.
only contour bunding taken up; comprehensive soil conservation programmes are being taken up only in the river valley projects of the chambal and the mahanadi.	—	—	work done in the command areas of river valley projects; progress upto March, 1971 =1860 hectares.

APPENDIX

1	2	3	4
Maharashtra	soil surveys are being carried out in the command areas as well as of the dry farming areas since 1966–67; so far 6 lakh hectares have been surveyed and mapped by the state department; besides, all India soil and land use survey organisation has covered 3.4 lakh hectares in the ghod catchment.	nine agro-climatic zones differentiated based on soils, climate, crops as follows:— (1) very high rainfall zone with lateritic soil (2) very high rainfall zone with non-lateritic soil (3) ghat zones (4) transition with red to reddish brown soil (5) transition with greyish black soil (6) scarcity zone (7) assured rainfall zone with mainly kharif crop (8) moderate to moderately high rainfall zone with soils formed from trap (9) high rainfall zone with soils formed from mixed rocks.	contour bunding and graded bunding (52.45 lakh hectares), terracing (0.81 lakh hectares) afforestation, reclamation of water logged areas, khar land development, nallah bunding, land development for irrigation, land development-cum-horticulture, grass land development, agave plantation and land development, flooding scheme and ravine reclamation. area covered by March 1971=54,77,992 hectares.

18.4 (*Contd.*)

5	6	7	8
zone 1 : on higher slopes above 10% where soils are not suitable for terracing horticultural canopy by plantation of cashew and mango; on lower slopes upto 10%—levelled terraces. *zone* 2 : as above. *zone* 3 : as above. *zone* 4 : terracing in verkas land upto 10% slope, contour bunding upto 6% slope, trenching and afforestation in other areas and reclamation of ill-drained dry lands. *zone* 5 : graded bunding with gully plugging for cultivable areas having slope above 0.5%; land development-cum-agave plantation in uncultivable areas; reclamation of ill-drained dry areas. *zone* 6 : contour bunding with gully plugging in cultivable areas having well drained soils, with slopes above 0.5% upto 6%; graded bunding in cultivable areas having ill-drained soils with slopes above 0.5%; land development - cum-agave plantation in uncultivable areas; reclamation of ill-drained dry lands. *zone* 7 : graded bunding with nallah draining in cultivable areas with slopes above 0.5%; land development-cum-agave plantation in uncultivable areas;	a study of economics of bunding in Maharashtra during 1959-60 to 1962-63 show : (i) an increase in yield per acre in bunded area in case of bajra—44.43% and in case of rabi jowar 35 to 69%; comparing the crop yield data of pre-bunding and post-bunding periodsit was found that bajra yield increased by 33.75% and rabi jowar yield by 32.5%. (ii) water-level in the wells in post-bunding period had increased on an average by 3.7 ft. (iii) after bunding, the cultivators bring under cultivation the uncultivated portions of their land; addition in area thus made—2.46%. (iv) due to larger quantity of water in wells of bunded areas, an increase in area under irrigation in the bunded area to the extent of 98.1% has taken place compared to area under irrigation before bunding. (v) cultivators change or adjust their cropping pattern after bunding and more areas have been brought under cultivation of cash crops like cotton, groundnut, etc.	by crop cutting experiment.	pocket filling is carried out along with contour bunding in scarcity areas; no land shaping work is done at present.

APPENDIX

1	2	3	4
Karnataka	soil surveys were initiated by the state department in 1966-67 in the command areas of the irrigation projects included in the fourth and fifth plans and government waste lands; so far 9.60 lakh hectares have been surveyed. The Bangalore centre of the all India soil and land use survey organisation is also carrying out surveys in the catchment areas of river valley projects falling in the State.	eight zones differentiated based on soil and climate as follows : (1) coastal region (2) hilly region (3) transition north (4) transition south (5) transition north east (6) dry north (7) dry central (8) dry south eastern	contour bunding alone is done. area covered by March, 1971 10.00 lakh hectares.
Nagaland	soil survey has been carried out in the soil conservation pilot project at zubza only.	no agro-climatic zones differentiated.	bench terracing only.

18.4 (*Contd.*)

5	6	7	8
reclamation of drained dry lands. *zone* 8 : terracing of verkas lands upto 10% slopes; graded bunding with nallah draining in other cultivable areas with slopes above 0.5%; trenching and afforestation in uncultivable areas; improvement of drainage in ill-drained soils. *zone* 9 : as in case of zone 6.			
contour bunding with cross sections of 8 sq ft., 10 sft., 14 sq ft and 16 sft., are being adopted according to soil type with suitable surplussing arrangements	No assessment has so far been made.	—	no land shaping work done.
it is localised.	no assessment has so far been made.	—	land shaping work done in the pilot project of zubza.
	assessment work initiated.		

APPENDIX

1	2	3	4
Orissa	standard soil survey is being continued in problem watersheds, command areas of existing and proposed irrigation projects, IADP district and other intensive agriculture blocks; the all India soil and land use survey organisation has undertaken surveys of the catchment area of the hirakud and machkund river valley projects.	reasonable demarcation is as follows: (1) northern plateau (2) central river basin (3) eastern hills (4) coastal plains.	contour bunding (85,000 hectares); stone terracing (1,750 hectares); field bunding (320 hectares); bench terracing (400 hectares); gully control—272 kms and 685 nos; stream bank erosion control 960 kms and 165 nos; land shaping and land development 1400 hectares; land development - cum-plantation— 13,573 hectares. total : 102,443 hectares.
Rajasthan	work regarding soil conservation works in chambal project is available.	—	information relate to the project taken in the catchment area of the chambal river valley project; pasture development and afforestation including trenching and contour bunding and terracing— 24,200 hectares by March, 1967 and other engineering works.
Tamil Nadu	so far 22.66 lakh hectares have been reconnaissance surveyed and 32 thousand hectares surveyed in detail; while preparing soil conservation schemes, soil survey and land capability classification data are duly considered.	no scientific demarcation made but can be divided into three zones based on rainfall : (1) low rainfall zone having precipitation of 50—100 cm (2) medium rainfall zone (rainfall 100—127 cm) (3) high rainfall zone (rainfall above 127 cm).	*hill areas :* bench terracing, contour trenching and gully control measures, construction of contour stone wall. *plain areas :* contour bunding, contour or staggered trenching, gully control measures, soil saving dams, field drains, land

18.4 (*Contd.*)

5	6	7	8
contour bunding with a consolidated section of 7 and 8 sq ft; bunds of various dimensions, stone terracing and bench terracing tried with success in the hilly areas where there is pressure on land and soil depth is adequate; cashew plantation in the coastal sand dunes and the adjoining lateritic uplands; casuarina grown as a wind brake and shelter brake in the coastal sand dunes; agava *sisalana* grown in eroded waste lands; farm ponds, diversion ditches, percolation tanks popular in hilly districts.	crop cutting experiments in contour bunded lands have shown increases in yield of different upland crops like ragi, suan, alsi in Koraput district and paddy, jowar, arhar and til in Sundergarh district, the percentage increases in yield of above mentioned crops are 45.7, 40, 33.3, 42, 40, 75 and 50 respectively.	crop cutting experiment.	proposed to be done in command areas of river valley projects.
—	no assessment made except command area of chambal river valley project. (details not available).	—	—
contour bunds designed either by fixing the horizontal intervals between two consecutive bunds and working out the cross section of the bund or by fixing the cross section of the bund and working out the horizontal interval to suit the	on bench terraced lands in the Nilgiris, increase in yield of potato 27% on an average; on contour bunded land in plains increase in the yield of cholam and cumbu 42% and 24% respectively; contour bunding followed by improved conservation methods results	—	scheme envisages control of irrigation and drainage water with suitable water management practices, water from the main channel is distributed through farm and field channels with needed control structures; zig-

APPENDIX

1	2	3	4
			levelling and grading, wind erosion control etc. area covered till March, 1971 3.85 lakh hectares.

Uttar Pradesh	soil surveys being carried out in areas where soil conservation measures are being taken which are spread all over the state.	three agroclimatic zones differentiated as follows:— (1) hill region (2) gangetic alluvium (3) central plateau	bench terracing, levelling, contour cultivation, water ways, diversion, channels, pasture development, development of fruit orchards, contour bunding and water harvesting. Progress of work done by March, 1971 is 11.70 lakh hectares (hill region—0.08 lakh hectares, gangetic Alluvium—7.43 lakh hectares, central plateau—4.19 lakh hectares).

18.4 (*Contd.*)

5	6	7	8
site conditions.	in average increase of crop yield to the extent of 65.62 per cent.	—	zag bigger bunds will be removed and laid as straight smaller sized bunds to facilitate the use of improved implements besides control of rodents; land levelling is undertaken for efficient use of water.
bench terracing formed by constructing a series of platforms across the hills slopes by half cutting and half filling; these are constructed on steep slopes ranging from 16-2/3 to 33-1/3% where soils are deep.	water table in the wells in and around the areas covered with soil conservation measures has risen.		as a pilot measure a scheme for reclaiming and shaping the land on the above said lines, an area of about 400 acres was selected in chithamatti village of mannargudi taluka of Thanjavur district.
contour stone walls are constructed on hills slopes, where depth of soil is very shallow on slopes ranging from 10 to 33-1/3% size 2' wide at top level and 1-1/2, above the ground level.			a scheme to take up work in irrigation command area of Sathanur project in North Arcot district sanctioned during 1969-70; area covered by 1970-71 about 344 acres (139.2 ha).
(*i*) *hill region :* bench terracing, levelling, contour cultivation, water ways, diversion channels, masonary structures for disposal of excess runoff, pasture development and development of fruit orchard and fruit belt.	average increase in yield of crops from the field which were bunded alone, levelled alone and where both bunding and levelling was done was about 39%, 59%, and 99% respectively.	crop cutting experiments in the pilot project area, Halwapur, Lucknow during 1958-65.	a centrally sponsored scheme of ravine reclamation covering an area of 2000 hectares is recently started; under this scheme, one of the items of development would be land levelling.
(*ii*) *gangetic alluvium* : contour bunding, levelling, afforestation, pasture development, and masonary structures for disposal of excess runoff.			

APPENDIX

1	2	3	4
Punjab	soil surveys not carried out; reconnaissance surveys started in Ludhiana and Hoshiarpur districts. Detailed soil survey of the regional soil and water management pilot project, Patiala (23.5 sq. miles) has already been completed.	factors like rainfall topography and availability of underground water for irrigation delineate the state into 3 Agro-climatic zones; (i) northern or foot hill zone (ii) central plains, and (iii) southern dry zone.	installation of underground pipe lines, construction of open brick masonary channels and grading of land; techniques of these measures differ from region, area covered by 1971-72 : contour bunding and gully reclamation 61,440 hectares, bench terracing 13,820 hectares; land grading and water management measures 40,490 hectares; field drainage 900 channelising and underground water pipes 55.2 lakh ft.

18.4 (*Concld.*)

5	6	7	8
(*iii*) *central plateau:* All the measures included under item (ii) above besides water harvesting systems to store surplus rain water.			
(*i*) *foot hill region* contour bunding diversion channels, disposal structures, gully reclamation, bench terracing, checks dams and nalahdraining works; contour bunds of 8 sq. ft. cross section area being constructed. (*ii*) *central plains :* with flat soils and ground water level pretty high measures, to save wastage of irrigation water as well as to ensure uniform irrigation throughout the field, practised are grading of land, underground water pipe conveyance system and lining of common water course.	in the contour bunded areas, the increase in foodgrains yield is 1/7th tonne per acre; underground pipelines results in saving of land and labour; lining makes 25-30% additional irrigation possible.	crop cutting experiments.	land grading and water management measures carried out in an area of 40,490 hectares land shapping ensures uniform irrigation resulting in uniform crop stand, avoids over irrigation and leaching of the plant foot and avoids damage to the crop due to stagnation of water.
(*iii*) *southern dry zone:* with water breakage and low rainfall, the successful steps like lined water courses for preventing seepage and percolation losses and levelling of land are being taken.			

APPENDIX 18.5

(Paragraph 18.4.10)

Sediment Data of Main Rivers and their Tributaries and the Corrected Values

Region No.	River	Site	Catchment area in sq km	Period of obs.	Average annual runoff in ham	* Average annual suspended load in ham
1	2	3	4	5	6	7
I	Narmada	jamtara	16,949	1956-58, 60, 60-64	630,548	800
I	Narmada	garudeshwar	87,931	1955-59 and 62	2,496,993	6,369
I	Chenab	kanthan	19,516	1965-69	1,688,585	3,067
I	Marusudar	tiller	2,797	1964-69	461,652	210
I	Ujh	panchtirthi hill	868	1961-63	138,087	584
I	Barak	lakhipur	14,504	1955-62	1,652,061	473
II	Bhima	takali	34,312	1966-68	715,787	882
II	Godavari	mencherial	104,105	1967-68	1,374,581	1,466
II	-do-	polavaram	432,328	1967-68	8,257,235	5,905
II	Sungabhadra	bavapuram	67,967	1966-68	588,720	635
II	Krishna	deosugar	131,015	1965-70	5,178,359	6,441
II	Penganga	penganga br.	22,406	1966-68	263,669	619
II	Wanganga	pauni	35,936	1966-68	1,297,362	1,794
II	Wardha	bamni br.	46,558	1966-68	1,350,936	1,638
II	Arun	tribeni	34,654	1955-63	19,911,030	2,857
I	Ganga	farraka	963,053	1963-66	8,865,066	39,329
I	Kamla	chisapani	1,562	1957-64	147,217	362
I	Sapt-kosi	sonakhambhi	59,539	1955-63	3,727,635	7,231
I	Son-kosi	tribeni	18,985	1955-63	2,161,132	3,649
I	Tamur	tribeni	5,900	1955-63	1,120,367	2,484
I	Tons	purawafall	5,439	1960-63	189,230	97
I	Trisuli	t. bridge	4,170	1963-70	74,984	805
I	Brahmaputra	pandu	424,131	1955-62 1965-69	46,451,137	20,885
I	Buridhihing	khowag	7,268	1955-62	1,314,461	1,175
I	Bebang	jiagaon	11,885	1957-62	3,307,399	2,189
I	Dessang	nanglamara ghat	2,890	1955-62	387,991	192
I	Dehang	rangghat	264,690	1958-62	18,551,930	14,413
I	Dikhu	sibsagar	3,196	1955-66	381,577	185
I	Dikrong	dikrong ghat	1,373	1955-62	276,016	305
I	Jhanji	tetalguri	956	1956-62	169,516	52
I	Luhit	digarughat	18,648	1957-62	4,621,304	4,658
I	Manas	mathanguri	36,333	1955-62	3,764,457	1,998
I	Noadhing	namsai	2,694	1958-62	359,100	352
I	Ranga nadi	ranga nadi ghat	2,202	1955-63	297,628	144
I	Subansiri	bhimpura ghat	26,400	1955-63	5,107,993	2,230
I	Testa	anderson br.	7,770	1962-65	2,009,875	4,705

* Wherever indication is not made sediment concentration is assumed as at the depth of mean sediment concentration.

APPENDIX 18.5 (*Contd.*)

Sediment Data of Main Rivers and their Tributaries (Contd.)

Region No.	River	Site	Annual rate of silting in ham/100 sq km	Calculated values of average annual suspended load in ham: correction factor due to sampling error**	Calculated values of average annual suspended load in ham: adding bed load on the basis of Maddock table***	Annual rate of silting in ham/100 sq km	Per cent mechanical composition of suspended sediment load: C	M	F	Average annual concentration of total sediment load P.P.M.
1	2	3	8	9	10	11	12	13	14	15
I	Narmada	jamtara	4.71	910	1,092	6.43	5	41	54	1,732
I	Narmada	garudeshwar	7.24	6,618	7,279	8.24	5	8	87	2,060
I	Chenab	kanthan	13.34	3,932	4,915	25.20	33	32	45	2,910
I	Marusudar	tiller	7.48	273	327	11.67	22	27	51	708
I	Ujh	panchtirthi hill	67.17	627	690	40.88	9	16	75	4,072
I	Barak	lakhipur	3.24	615	664	4.57	2	9	89	401
II	Bhima	takli	2.57	922	996	2.86	..	14	86	1,391
II	Godavari	mencherial	1.43	1,510	1,524	1.43	1	8	91	1,070
II	-do-	polavaram	1.33	5,232	5,650	1.29	1	13	86	689
II	Tungabhadra	bavapuram	1.00	691	726	1.05	..	4	96	1,232
II	Krishna	deosugar	4.91	6,582	6,911	15.29	1	6	93	1,334
II	Penganga	penganga br.	3.34	624	655	3.53	..	2	98	2,483
II	Wanganga	pauni	5.00	1,818	1,909	3.58	..	4	96	1,471
II	Wardha	bamni br.	3.53	1,688	1,773	3.81	1	9	90	1,311
II	Arun	tribeni	8.24	3,289	4,111	11.91	24	26	50	2,065
I	Ganga	farraka	4.09	39,772	41,803	4.33	1	4	95	4,715
I	Kamla	chisapani	22.34	390	448	28.72	10	15	75	3,044
I	Sapt-kosi	sonakhambhi	12.15	8,207	9,849	16.52	15	30	55	2,642
I	Son-kosi	tribeni	19.24	4,136	5,170	27.20	17	27	56	2,392
I	Tamur	-do-	42.10	2,866	3,582	60.76	26	27	47	3,510
I	Tons	purawafall	1.81	101	106	1.95	11	11	88	559
I	Trisuli	t. bridge	19.29	935	1,169	28.00	29	25	46	1,556
I	Brahmaputra	pandu	5.43	30,512	33,563	7.81	3	20	77	722
I	Buridhihing	khowang	16.15	1,269	1,383	17.43	7	20	73	1,052
I	Debang	jiagaon	18.43	2,507	3,134	26.34	17	31	52	947
I	Dessang	nanglamara ghat	6.62	201	211	7.29	3	13	84	543
I	Dehang	rangghat	5.43	1,694	2,118	7.95	22	36	82	1,141
I	Dikhu	sibsagar	5.76	190	200	6.28	2	8	90	524
I	Dikrong	dikrong ghat	22.24	330	357	25.96	9	18	73	1,292
I	Jhanji	tetalguri	5.48	56	60	6.29	3	17	78	355
I	Luhit	digarughat	24.96	5,318	6,382	34.20	21	26	53	1,380
I	Manas	mathanguri	5.48	2,597	2,805	7.88	9	24	67	754
I	Noadhing	namsai	13.05	382	401	14.86	5	24	71	1,117
I	Ranga nadi	ranga nadi ghat	6.52	159	183	8.29	14	21	65	613
I	Subansiri	bhimpuraghat	8.44	2,506	2,882	10.91	17	24	59	564
I	Testa	anderson br.	60.54	6,117	7,646	98.40	34	28	38	3,894

** Correction factor = (C+M) × 1.30 + F.

*** Total sediment load = Total suspended load plus bedload assumed to be 20% of the total suspended load (according to Maddock's table).

APPENDIX 18.6

(Paragraph 18.5.23)

Statewise Projects with Catchment Area and Gross Capacity

S. No.	Name of Project	Catchment area (sq km)	Year of completion	Gross capacity in hectare metre (in acre feet)
1	2	3	4	5
	Andhra Pradesh			
1.	Nizam sagar . . .	21673	1931	86,132 (6,82,060)
2.	Bhaira yentippe . .	14392	1961	7,389 (59,900)
3.	Dindi	3920	1943	7,389 (59,900)
4.	Kaddam	2590	1937	21,525 (1,74,500)
5.	Koil sagar. . . .	1836	1955	5,05,000 (40,535)
6	Munnair . . .	2165	1950	8,500 (68,909)
7.	Musi	9091	1963	14,242 (1,15,449)
8.	Nagarjuna sagar . .	228605	1970	11,55,883 (93,70,000)
9.	Palair	1693	1928	7,248 (58,755)
10.	Upper pennar . . .	5245	1958	8,511 (69,000)
11.	Pincha	1683	1960	900 (7,296)
12.	Pochamapad . . .	90725	V Plan	3,17,035 (25,70,000)
13.	Pallapadi	2201	1948	3,100 (25,131)
14.	Sagileru lower . . .	1797	1959	354 (2,875)
15.	Sarlassagar . . .	1217	1959	709 (5,750)
16.	Machkund . . .	2222	1959	76,977 (6,24,000)
17.	Himayet sagar . . .	1313	1926	10,780 (87,386)

APPENDIX 18.6 (*Contd .*)

1	2	3	4	5
18.	Yamsadhara	9768	yet to be started	45,631 (3,69,900)
19.	Srisailam	206778	1965	8,72,155 (70,70,000)
20.	Mada nagar	12651	1931	3,33,803 (2,74,016)
21.	Sagar pam lower . .	1820	1959	318 (2,574)
22.	Sinla sagar	1235	1959	1,41,400 (11,349)
	Assam			
23.	Umiam	N. A.	stage I in 1965 stage II in IV Plan	18,18,134 (1,47,000)
	Bihar			
24.	Tillaiya (DVC)	984	1953	39,475 (3,20,000)
25.	Subarna rekha . . .	88	1968-1976	200 (1,622)
26.	Konar (DVC) . . .	1001	1955	33,677 (2,73,000)
	Gujarat			
27.	Shetrunju	4317	1966	35,003 (2,83,748)
28.	Dhanti wada (banas) .	28620	1967	47,244 (3,82,655)
29.	Narmada stage I (branch)	88549	Not fixed	6,81,564 (55,25,000)
30.	Ukai	62222	1971	8,51,184 (69,00,000)
31.	Mali stage II (Kadana) .	25485	V Plan	1,74,184 (14,12,000)
	Haryana			
32.	Bhakra nangal	56978	1963	9,34,452 (75,75,000)
33.	Beas project unit I (Panchole-beas Sutlenge link) . .	1256	1959-60 (started)	2,000 (16,214)
34.	Beas project unit II (Pong) .	5283	1963 (started)	

APPENDIX 18.6 (*Contd.*)

1	2	3	4	5
	Karnataka			
35.	Chamaraja sagar . .	1378	1933	6,739 (54,637)
36.	Krishna raj sagar .	10660	1932	157 (1,279)
37.	Maikonahally . . .	10668	1941	6,579 (53,339)
38.	Ghataprabha . . .	1417	V Plan	66,609 (5,40,000)
39.	Bhadra	1969	IV Plan	2,02,294 (16,40,000)
40.	Malaprabha . . .	2176	V Plan	87,949 (7,13,000)
41.	Upper Krishna . .	36065	V Plan	2,38,682 (19,35,000)
42.	Harrangi	2346	1968	19,243 (1,56,000)
43.	Hemawathi . . .	2821	V Plan	65,376 (5,30,000)
44.	Saravathi . . .	2046	stage I—1965 stage II-III Plan stage III spot fixed	4,41,593 (35,80,000) 14,062 (1,14,000)
45.	Hagari	1881	N.A.	5,700 (46,209)
46.	Kabini	5283	1966	54,400 (4,41,020)
47.	Nalamparabha . . .	2176	N.A.	88,000 (7,13,416)
48.	Siddapur	47848	1971	79,100 (6,41,263)
49.	Vamivilas sagar . .	5374	1907	84,952 (6,88,705)
	Kerala			
50.	Malampuzha . . .	N.A.	1967	23,622 (1,91,500)
51.	Kallada	551	V Plan	51,728 (4,25,000)
52.	Sabargiri (Pambe) . .	N.A.	1967-68	4,053 (32,855)
53.	Scholayar . . .	2600	1967-68	15,420 (1,25,000)

APPENDIX 18.6 (*Contd.*)

1	2		3	4	5
54.	Iddiki		2600	V Plan	2,49,804 (16,20,000)
55.	Poriyar		presumed loss barrage	1897	
	Madhya Pradesh				
56.	Tendula		871	1910	12,428 (1,00,756)
57.	Maramsilli . . .		487	1923	16,534 (1,34,045)
58.	Maniesi		806	1933	15,127 (1,22,635)
59.	Gandhi sagar (in project)	Chambal	26935	1960	6,51,041 (52,78,000)
60.	Tawa		51983	1976	2,31,158 (18,74,000)
61.	Bama		1176	1974	46,500 (3,76,975)
62.	Maniam		803	1933	15,049 (1,22,000)
63.	Kharung		614	1931	1,961 (15,895)
64.	Harsi		1880	1935	19,121 (1,55,016)
	Maharashtra				
65.	Maaswad dam . . .		1248	1888-89	8,697 (70,505)
66.	Tansa dam . . .		137	1922	18,441 (1,49,500)
67.	Wilson dam . . .		128	1926	N.A.
68.	Ilod dam		333	1928	68,531 (5,55,586)
69.	Musi		249	1929	N.A.
70.	Radhanagri . . .		111	1951	23,437 (1,90,000)
71.	Ghod		3629	1965-66	21,586 (1,75,000)
72.	Bagh		169	IV Plan	20,353 (1,65,000)
73.	Girna		4729	IV Plan	61,182 (4,96,000)
74.	Itiadoh		707	IV Plan	46,996 (3,81,000)

APPENDIX 18.6 (*Contd.*)

1	2	3	4	5
75.	Mula	2274	IV Plan	73,640 (5,97,000)
76.	Purna	7329	IV Plan	96,213 (7,80,000)
77.	Bhima (ujjani) . .	14856	n.a.	3,13,699 (25,43,165)
78.	Krishna	n.a.	not yet started	3,787 (30,700)
79.	Warna	n.a.	V Plan	28,617 (2,32,000)
80.	Koyna (stage I, II and III) .	895	1963	2,77,583 (22,50,000)
81.	Vaitarna	n.a.	IV Plan	31,948 (2,59,000)
82.	Vir	1756	1965	27,900 (2,26,185)
83.	Jayakwadi stage I . .	21755	n.a.	3,34,510 (27,11,873)
84.	Muna stage II . .	1885	n.a.	13,800 (1,11,876)
85.	Khadakvasla stage I . .	22095	n. a.	23,800 (1,92,946)
86.	Nagar stage II . . .	1585	n. a.	23,800 (1,92,946)
	Orissa			
87.	Hirakud . . .	83395	1960	8,14,110 (66,00,000)
87A.	Balimela . . .	4927	V. Plan	2,83,705 (23,00,000)
88.	Ranapratap sagar .	24856	IV plan	2,89,873 (23,50,000)
89.	Jawahar sagar (kotah dam)	26936 including gandhi sagar of ranapratap sagar.	IV plan	4,800 (38,914)
90.	Mahi stage II . . .	4258	1960	1,69,606 (13,75,000)
91.	Broach at badgaon .	1699	1967	3,100 (25,132)
92.	Barachat ballavh nagar .	1248	1965	3,100 (25,132)
93.	Moral	2201	1954	7,700 (62,425)

APPENDIX 18.6 (*Contd.*)

1	2	3	4	5
	Tamil Nadu			
94.	Periyar dam	603	1897	44,350 (3,59,550)
95.	Mettur dam	42215	1934	2,70,903 (21,96,213)
96.	Thambraparni	333	1943	15,142 (1,26,000)
97.	Lower Bhavani	4201	1955	92,901 (7,53,150)
98.	Kundah	1266	..	Integration of reservoirs
99.	Sathnar	10868	1958	12,927 (1,04,800)
100.	Vaigai	2253	1959	19,500 (1,58,088)
101.	Raizat Sathanpur stage I	10826	1958	22,900 (1,85,653)
102.	Vidur	1298	1959	1,700 (13,781)
103.	Krishnagiri	5428	1959	6,837 (55,430)
104.	Manimuthar	162	1958	17,679 (1,43,323)
105.	Lochuna dam	8892	1910	3,596 (29,155)
106.	Pahari	7868	1913	7,934 (64,325)
107.	Gajar dam	2868	1917	15,253 (1,23,655)
108.	Matatilla	20719	1966	1,12,989 (9,16,000)
109.	Ramganga	3077	1972	2,19,563 (17,80,000)
110.	Rihand	13385	1966	10,60,810 (86,00,000)
111.	Obra	n. a.	IV Plan	21,093 (1,71,000)
112.	Mejha	2020	1967	18,441 (1,49,500)
113.	Murakhand	5333	..	11,348 (92,000)

APPENDIX 18.6 (*Concld.*)

1	2	3	4	5
114.	Ghagar	2858	1917	15,295 (1,24,000)
115.	Nanak Sagar . . .	220	1962	19,983 (1,62,000)
	West Bengal			
116.	Mayurakshi . . .	1860	1956	
117.	Kangsabati . . .	3789	IV plan	1,13,482 (9,20,000)
118.	Jaldhaka . . .	50 in West Bengal	1967	barrage
119.	Maithon (DVC) . .	2010	1958	1,35,685 (11,00,000)
120.	Panchet (DVC) . .	3790	1956	1,58,135 (12,82,000)
121.	Kangsabati (kumari) . .	3781	1973	1,13,501 (9,20,156)

19

ELECTRICITY IN RURAL DEVELOPMENT

1 INTRODUCTION

19.1.1 Electricity plays an important role in the agricultural production and the development of rural economy. Electricity is required for pumping for irrigation and domestic water supply, processing agricultural produce, cottage small and medium scale industries, and for providing amenities like lighting, heating and radio and television for entertainment and as an essential medium of instruction and education. Above all electricity modernises the entire outlook of the rural population and makes them progressive.

19.1.2 A number of studies made in recent years have shown that electricity makes a significant contribution in the development of agriculture. Some are mentioned below :

(i) The Programme Evaluation Organisation (PEO) of the Planning Commission made a study in 1961—65 of 2,460 households which included existing and prospective consumers in 210 villages covering 36 districts in 15 States. All the villages covered by this study were electrified before March 31, 1959. The study revealed that as a result of the installation of electric pumps on existing and new wells, irrigated area increased by 67 per cent for kharif crops and 65 per cent for rabi crops. The irrigated area per farmer increased from 2.43 hectares to 3.91 hectares. New crops were introduced and the intensity of irrigation increased substantially.

(ii) The Indian Institute of Management, Ahmedabad, conducted a study of the economics of rural electrification in Gujarat[1]. This showed that after electrification the average irrigated area per farmer had increased to 5.02 hectares from 2.08 hectares before electrification.

1 1969. Studies of Economics of Rural Electrification and Lift Irrigation (Gujarat State).

(iii) The National Council of Applied Economic Research (NCAER) made a study of the impact of rural electrification in Punjab[1] and another on the economics of rural electrification in Kerala[2]. The Punjab study showed that in the sample area there was an increase of 3.09 hectares in irrigated area per farmer due to electricity driven pumpsets and tubewells and that the farmer saved in labour 354 bullock-days per crop year. The Kerala study revealed a substantial change in the cropping pattern in favour of rice crop.

(iv) A study undertaken as a research project in Tamil Nadu[3] showed that after electrification the area under irrigation had increased by 36 per cent and the value of the crops produced had doubled.

19.1.3 Electric pumps are cheaper in capital and operation costs than diesel-operated pumps. Therefore, speedy development of groundwater for increasing agricultural production requires that electric power should be available for the purpose. This is particularly important in areas where there is paucity of surface water and groundwater has to be exploited to meet the agricultural and domestic needs. The impact of electricity on industrialisation of rural areas is also significant. A study made by PEO which investigated 479 industrial units revealed that more than 75 per cent of these were established after electricity was available in the area. The rest which already existed switched over to electricity due to economy in fuel cost. The average annual profit on these converted units increased by 11 per cent on electrification. Electric power is required for many purposes in agriculture. The setting up of cold storage plants in rural areas for storing perishable commodities like potato, fruit etc., not only saves on losses but also makes them available out of season. Electricity is required for animal husbandry and for many agro-based industries.

2 DEVELOPMENT OF RURAL ELECTRIFICATION

19.2.1 Fifteen years after Thomas Alva Edision built the first power station in USA, India had its first power station constructed in 1897 at Darjeeling. This was a 130 kw hydroelectric station. Thereafter, for many years the supply of electric power was confined to a few urban and industrial pockets. Generation, transmission and distri-

1 1967. Impact of Rural Electrification in Punjab, NCAER.
2 1970. Economics of Rural Electrification in Kerala, NCAER.
3 1969. Electricity and Economic Development of Madras State, by Prof. K. S. Sonachalam. Research Programme Committee, Planning Commission, Government of India.

bution were mostly done by private electric supply undertakings who paid little attention to taking electricity to the rural areas. This was largely due to the fact that rural electrification serving scattered and seasonal loads with poor load factors gave low return on investment. Till the attainment of Independence in 1947, only 1,300 villages had been electrified and about 6,400 pumpsets energised in this vast country.

19.2.2 After Independence, the responsibility for power generation, transmission and distribution was taken over by the Government. State electricity boards were formed with the enactment of the Electricity (Supply) Act 1948, and thereafter rural electrification began to receive attention. Even so, the progress was initially tardy as rural electrification was not accorded the priority it deserved. It, however, gained considerable momentum during the sixties when speedy development of groundwater for increasing agricultural production received special attention.

19.2.3 The progress of rural electrification in the successive plan periods is indicated in Table 19.1.

TABLE 19.1

Villages Electrified and Pumpsets Energised

(number)

Period	Villages electrified	Pumpsets energised
Beginning of the First Plan	3,061	21,008
During the First Plan (1951—56)	4,233	35,045
During the Second Plan (1956—61)	14,456	142,841
During the Third Plan (1961—66)	23,394	313,837
During 1966-67	9,369	136,231
During 1967-68	8,023	290,482
During 1968-69	11,186	239,305
During the Fourth Plan (1969—74)	81,575	1,352,953
End of the Fourth Plan	155,297	2,441,602

It will be noticed that there was a spurt in rural electrification in the Third Plan. Thereafter, the tempo has progressively been stepped up. During the Fourth Plan more villages were electrified and pumps energised than the total number upto the beginning of the Fourth Plan. The statewise investment on rural electrification in successive plans is given in Appendix 19.1. The statewise number of villages electrified to the end of successive plans is given in Appendix 19.2, while the pumpsets energised are shown in Appendix 19.3.

3 PROGRAMME AND POLICIES

19.3.1 The draft Fifth Plan envisages the electrification of about 1.5 million pumpsets during the plan period which will bring the cumulative total to about 4 million at the end of the financial year 1978-79. According to available information, there would still be about 5.5 million wells which could be economically provided with electrical pumpsets. As regards electrification of villages, the draft Fifth Plan envisages electrification of 110,000 villages still leaving about 300,000 more to electrify, which is more than half the total number of villages in the country. We strongly recommend that the tempo of rural electrification should be stepped up so as to make electricity available for pumpsets and rural industries in practically all the villages by 1990.

19.3.2 Keeping in view the target of almost complete rural electrification by 1990, we recommend that the state electricity boards should prepare a well considered and coordinated programme of rural electrification in consultation with other development departments at the state, district and block levels. In particular, there should be the involvement of the Chief Agricultural Development Officer recommended by us in Chapter 62 on Administration in drawing up the detailed programme. It is important that the concerned departments and organisations should be consulted at the stage of programme formulation itself, as that gives better formulation and smoother implementation.

19.3.3 Advance planning for the future programme of electrification is essential and the State electricity boards should take early action on the following aspects :

(i) assessment of requirement of power and making arrangements to meet the same ;

(ii) assessment of requirement of Extra High Tension (EHT) and High Tension (HT) net works and initiation of appropriate action to meet the same ;

(iii) assessment of requirement of materials and arrangements for their indigenous procurement ;

(iv) assessment of requirement of personnel and arrangements for their training ; and

(v) carrying out of connected research and development work.

19.3.4 Many States are now experiencing an acute power shortage which has adversely hit all sections of the community. We, however, feel that though transitory the difficult power position should not be permitted to hamper agricultural development and during power shortage, the requirements of the agricultural sector should continue to be accorded a high priority. As large scale rural electrification pro-

gramme has to be carried out in the next three plans, it is very important that adequate and timely generation of electric power for meeting the load is ensured.

19.3.5 In order to make rural electrification financially and economically attractive, it is necessary to take steps to develop rural loads. These loads can be agricultural, industrial and domestic. The State Governments should discourage cluster growth of industries in and around the urban areas and should aim at dispersal of industries to rural areas. This could be done by providing basic facilities like electricity, land, water etc. at concessional rates and also encouraging financial institutions to offer loans on soft terms to the entrepreneurs who are willing to establish industries in the rural areas. We are glad to note that Government is following this policy.

19.3.6 The number of villages electrified and pumpsets energised in the various States in the country is given in Appendices 19.2 and 19.3. It is to be noticed that there is considerable disparity between the various States. Within a State itself there are areas which are not having the benefits of electricity, being either remote and difficult of access or thinly populated or very backward. We are glad that Government of India is paying special attention to such areas in the matter of electrification and that funds for the purpose are being distributed by the Rural Electrification Corporation out of the amount set apart in the Fifth Plan for the Minimum Needs Programme.

19.3.7 Under the special *Harijan Bastis Schemes,* the Government of India have placed some funds at the disposal of the Rural Electrification Corporation for granting loans to the State electricity boards for providing street lights in such harijan bastis as were left out while electrifying a village. We suggest that the State electricity boards should take advantage of this and see that the amenity of street lights is provided in all such harijan bastis within the next two years. The charges for the electricity consumed by these should be borne by the State Government concerned.

19.3.8 Under a scheme of the Ministry of Health and Family Planning, 50 per cent subsidy is allowed to the States for providing electricity to the primary health centres in distant places. We recommend that the State Governments should take suitable action to extend electricity to these primary health centres as quickly as possible, say in about two years. The primary health centres near transmission lines should be taken up first for reasons of economy.

19.3.9 There are several fishermen colonies along the sea coast which do not have the benefit of electricity. The electricity boards should give special consideration to extending electricity to these colonies to improve the living conditions of the fishermen.

19.3.10 There are several areas in the country which are recur-

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rently affected by famine or scarcity and large amounts are spent on relief works there. The famine codes and scarcity manuals do not provide for any expenditure to be incurred on rural electrification out of relief funds. We feel that if a programme of deepening of existing wells or digging of new wells in such areas is combined with that for providing electricity for them out of relief funds, it would be a step in the right direction. In the absence of electrification, the wells cannot give the optimum benefit. We would recommend that the Central and State Governments should consider this aspect.

4 ECONOMICS OF RURAL ELECTRIFICATION

19.4.1 Commercially, rural electrification is not attractive and therefore in the past, no licensee in the private sector extended the benefit of electricity to the rural areas except on a small scale. This activity had, therefore, to be taken up in the public sector to be carried out by the State electricity boards where formed. Under the provisions of the Electricity (Supply) Act, 1948, these boards have been charged with the responsibility for coordinated development of generation, supply and distribution of electricity, within their respective jurisdiction, in the most efficient and economical manner, with special emphasis on such development in areas which for the time being are either not served or are inadequately served. Section 59 of the Act also lays down that the electricity boards shall not as far as practicable, carry on their operations at a loss. The implication is that the boards should attempt to realise adequate revenue to cover the operation and maintenance charges, interest on loan capital, contribution to general depreciation reserve and energy charges. As the return on capital investment on rural electrification schemes is very low initially and reaches a satisfactory level only after a gestation period of 10 to 15 years, rural electrification strains financial resources of the boards.

19.4.2 The most important use of electricity in rural areas is for pumping water. The cost of energising a pumpset is dependent on factors like proximity to sub-transmission or distribution line, existence of cluster of wells etc. On the basis of the schemes sanctioned by the Rural Electrification Corporation for loan assistance involving energisation of 558,000 pumpsets, the cost per pumpset, inclusive of village electrification, comes to about Rs. 5,360. For the energisation programme in the Fifth Plan the cost may be of the order of Rs. 6,000 per pumpset allowing for some increase in the cost of materials and labour. Taking the pumpset to be of 5 hp and a load factor of 15 per cent, an investment of Rs. 6,000 would give a cost of 15 paise per

kwh on allowing for 6 per cent interest, 5 per cent depreciation and 3 per cent operation and maintenance charges. To this has to be added the cost of generation ranging between 5 and 14 paise per unit and that of transmission. On a reasonable tariff for agricultural use of power, which cannot be pitched high as a matter of State policy, there is invariably a loss to the electricity board in the initial years till the load builds up. It is, therefore, very important for keeping the tariff at a viable minimum to bring about maximum economy in capital costs without sacrificing safety considerations and also to take steps to improve the load factor and thus the revenue through larger use of power as early as possible.

19.4.3 Economy can be achieved through standardisation of equipment and materials used in rural distribution systems, simplification of designs for construction while meeting the safety requirements and utilising local materials to the extent possible. Standardisation of materials should naturally cover reduction in the variety of material so that inventory of items required for construction, operation and maintenance is kept at the minimum. Such a reduction will help smooth construction and avoid delays. Mass production will also be possible leading to a reduction in cost. The Rural Electrification Corporation has already taken up the work of standardisation and this should continue to receive sustained attention.

19.4.4 In the distribution of power, a certain amount of line loss is inevitable but this should be kept at the minimum. In planning the layout of distribution lines a careful economic study should be made not only with the loads which they have to cater for immediately but also for further loads which may develop there in the near future. The revenue losses accrue from poor distribution layout resulting in high voltage drops, incorrect metering due to faulty meters at consumers' premises and theft of energy by dishonest consumers, etc. These losses are abnormally high in several areas. The electricity boards should take urgent steps to bring down the losses in the existing systems and ensure that future distribution systems are designed to give only tolerable line losses and malfunctioning and malpractices are remedied.

19.4.5 Notwithstanding the economy in construction and improvement in operation and maintenance, a power tariff for rural loads remunerative to the state electricity boards, is bound to be higher than what the rural community can bear. The power rates have therefore to be kept lower than what would normally be commercially justified. In view of this, the Rural Electrification Corporation gives soft loans to the boards for rural electrification, which is an indirect subsidy.

19.4.6 Theft of power unless put down firmly can be widespread. For salutary effect punishment for this offence has to be prompt and

adequate. Cases of theft of energy and certain other malpractices are covered by Sections 39, 40, 44, 46 and 47 of the Indian Electricity Act, 1910. These, however, do not empower the board to disconnect the supply. The board can only initiate prosecution under Section 50 of the Act involving an elaborate procedure. The onus for the evidence for the offence committed by the consumer rests with the board. In view of these difficulties, not many prosecutions are launched even when offences are discovered. The Andhra Pradesh State Electricity Board, however, has armed itself with powers to disconnect supply to any consumer caught committing such malpractices. This was done by the board by modifying its terms and conditions of supply under Section 49(i) of the Electricity (Supply) Act, 1948 and by incorporating therein the power to disconnect. Certain consumers had challenged this action in the court of law but the action of the State electricity board in disconnecting the supply in the various cases was upheld by the High Court. We recommend that other State electricity boards may adopt a similar procedure. We would however like to caution that the power to disconnect should be exercised only by a responsible officer of the board. Frequent surprise inspections, particularly of agricultural and industrial installations in remote areas would greatly discourage any unauthorised use of electric power.

19.4.7 Rural electrification should not be viewed from the limited financial angle. Its far-reaching economic and social benefits, however, are not apparent. It is important that studies should be organised to evaluate the benefits of rural electrification and the results widely publicised.

5 FINANCING OF RURAL ELECTRIFICATION SCHEMES

19.5.1 Rural electrification in most of the States is being carried out by the State electricity boards. Where electricity boards have not been formed as also in the Union Territories, this work is being carried out directly by the electricity departments concerned with funds provided by Government. The State electricity boards derive funds for the purpose from the following sources :—

(i) their own profit ;
(ii) loans from the State Governments ;
(iii) loans from the Rural Electrification Corporation ;
(iv) special loans from the Central Government for specific schemes like tribal area development or Emergency Agricultural Production Programme ;
(v) special loans from commercial banks, Life Insurance Corporation, and the agricultural finance corporations ;

(vi) market borrowings ; and
(vii) depreciation reserve.

19.5.2 Except for the First Plan, when the amount provided for rural electrification was not fully utilised, in all other plans, the actual expenditure had exceeded the outlay provided therein. This is indicative of the importance which was being attached to this developmental programme as will be seen from Table 19.2.

TABLE 19.2

Plan Outlay and Actual Expenditure

(Rs. crores)

Period	Plan outlay	Actual expenditure
First Plan	20	8
Second Plan	75	75
Third Plan	105	153
1966-67	62	74
1967-68	45	75
1968-69	43	89
Fourth Plan	520	819

Statewise details are given in Appendix 19.3.

19.5.3 Although the tempo of rural electrification was being stepped up from plan to plan, it was felt that the progress was not rapid enough and some special steps were required to meet the situation. Accepting the recommendations of the All India Rural Credit Review Committee, 1969, the Government of India formed that year the Rural Electrification Corporation (REC) as a Government owned company. The REC started operating in 1970. Under its charter, it is suitably funded. The financial arrangements include a substratum of interest-free grant, an element of equity and an appreciable proportion of borrowed funds. The main consideration underlying the arrangements for funding the Corporation was to enable it to provide long-term loans on relatively low rates of interest to State electricity boards for promoting schemes of rural electrification with developmental potential. In its directive, Government had enjoined that the REC should pursue a project approach to the various schemes, ensure appropriate standards

of economic viability for the projects and make some relaxation in the standards of the criteria thus evolved in favour of backward areas. The loans which the REC advances are long-term ones ranging from 20 to 30 years for repayment. Lower rates of interest are charged for backward areas. Till the end of 1974, the Corporation had sanctioned loans amounting to Rs. 363 crores for 791 schemes in 18 States. More than half the number of projects and appreciably more than half the sanctioned amount pertained to areas classified as backward or specially underdeveloped, including areas under the Minimum Needs Programme. We note that the draft Fifth Plan provides nearly Rs. 1,100 crores for rural electrification schemes, of which about Rs. 670 crores are to be channelled through REC including Rs. 270 crores under the Minimum Needs Programme. We suggest that the various State electricity boards should prepare and keep ready a large number of schemes to take full advantage of the loan facilities being provided by REC.

19.5.4 There are areas in several States where there are no transmission or subtransmission lines to build up rural loads. The REC gives special loan for the construction of such lines and the requisite substations, provided these are intended to serve loads in areas covered by the schemes accepted by the REC, and further if they meet certain criteria of expenditure. It is obvious that unless transmission lines are there, no load can be developed in an area. In backward and disadvantaged areas, therefore, it would seem necessary to provide transmission and subtransmission lines in advance of load requirement, though financially unattractive, to encourage development of the use of electricity. We suggest that in such cases, the Centre/State Governments should subsidise parts of the capital cost of the schemes to be incurred by the State electricity boards so as to satisfy the norms prescribed by the REC. Similarly, where villages are far away from each other and the inclusion of the cost of 11 KV lines makes the scheme for electrifying them unremunerative, the REC may consider giving special loans for the 11 KV lines by treating them as transmission lines. Also the State Governments should subsidise the unremunerative portion of such schemes.

19.5.5 While efforts are made to take electricity to rural areas in a big way, it is important that the users, mostly farmers and small scale entrepreneurs, are enabled to avail of the facility. For this, there has to be adequate credit facility for rural people to enable them to meet the cost of electrification including payment to the electricity boards for service connections. The credit facility should also be extended to such villagers as would like to electrify their homes but are unable to meet the initial cost. We have dealt with the subject of agricultural credit in Chapter 55 on Credit and Incentives.

6 DIFFICULTIES OF RURAL CONSUMERS

19.6.1 The rural consumer, especially the agricultural consumer, experiences several difficulties in the use of electricity. These mostly are (a) getting service connection for electricity supply, (b) procuring equipment of suitable capacity and of requisite quality at a reasonable cost, (c) maintenance of equipment, (d) interruptions in electric supply, (e) poor voltage conditions, and (f) getting wrong bills for electricity used. A Committee was constituted by the Government of India under the chairmanship of the Deputy Minister, Ministry of Irrigation and Power, to look into such difficulties and has since submitted its report to the Government. However, we would like to highlight some of the difficulties for the special attention of the Government.

19.6.2 In the matter of power supply, there should be a system of priorities based on the date of application and this should be strictly adhered to by the electricity boards. Complaints of delay should be promptly attended to. In many areas, most people do not know the procedure for applying for electricity. It is desirable that information in this respect is given through leaflets in the local language. We have separately recommended the formation of farmers' service societies as a registered body under the Co-operative Act to serve the needs of the rural people in the matter of inputs such as fertilisers, seeds, etc. A number of these societies have already been formed in some of the States. We recommend that it should be the responsibility of this society or the panchayat to look into the complaints and grievances of the people of its area in the matter of power supply and bring them to the notice of the concerned authorities for redressal.

19.6.3 The suppliers of equipment to the farmers sell whatever is available with them without a technical study of the real needs of the farmers. We recommend that the State agro-industries corporations should be charged with the responsibility for the supply of quality equipment at reasonable prices and for advising the farmers on the correct ones to use and their proper handling.

19.6.4 Maintenance of motors and pumpsets is a problem for the farmer in rural areas. In case of trouble, he has to take the equipment miles away for getting it repaired. There is not only waste of time but also some loss in crop production for want of irrigation water when during the prolonged period the equipment remains out of order. The Ministry of Agriculture & Irrigation had formulated a proposal for setting up of 5,000 agro-service centres for providing various services and supplies for rural areas depending on the local needs. Active steps should be taken to implement the scheme. The agro-service centres should have the services of licensed electrical wiremen/

electricians for attending to such repair work.

19.6.5 In many areas, the voltage of power is very low and this results in the burning out of electric motors. The farmer whose electric motor gets burnt has to depend on unscrupulous middle-men who extract large amount of money from him to get his motor rewound and put back into service. The agro-service centres should help the farmer in getting the motors rewound at reasonable rates. Also, the electricity board should take action to carry out necessary improvements in the system so as to maintain proper voltage conditions.

19.6.6 Defective meters and improper meter reading by the staff naturally result in wrong billing. If the bill is not paid, the supply is disconnected before the farmer can get redress by way of revision of the bill. Such contingencies, especially when the crops need watering, result in a great loss to the agricultural consumer. We recommend that pending investigation an interim payment on the basis of the average of the previous two months should be accepted, and the contested bill speedily investigated. There should be a time limit for such investigations after which the contention should be treated as valid. It is learnt that in Haryana, there is an enactment whereby a consumer is debarred from challenging a wrong bill before the higher authorities and from going to the court for redressal of his grievances unless he has made full payment of the wrong bill. We feel that the consumer should be given the opportunity of getting his grievance redressed before being made to pay the bill in full. Fictitious reading of meters which is generally the cause of wrong billing should be considered as a serious offence and the person found responsible for it should be suitably punished.

19.6.7 There should be fixed days/dates for each area/village for taking meter readings so that the farmer may arrange to be present at the time. The practice of providing a duplicate meter card at the consumers' premises which has been given up in some areas, should be reintroduced. In order to enable the consumers to make payment of the bills without having to go a long way to the electricity office, the system of sending the bill collectors to a specified place in the villages on specified days has been introduced by some electricity boards. It is recommended that this practice may be followed by others also with advantage.

19.6.8 There is considerable pilferage of electrical equipment such as transformers, conductors and even motors from tubewells and distribution system. Apart from the loss of these, the resulting interruption in electric supply or working of the pumps causes great hardship and loss to the power users. The State electricity boards should elicit the cooperation of the people in checking these offences and may offer suitable rewards for catching the culprits. The State electricity

boards may have with advantage special rapid moving squads for apprehending pilfering gangs. It is suggested that the relevant Sections of the Indian Electricity Act, 1910 and Electricity (Supply) Act, 1948 should be amended to make theft of transformers, conductors and other materials and the possession of such stolen articles a cognizable offence as theft cases. Standardised equipment used by an electricity board may be suitably stamped for facility of recognition.

19.6.9 For getting an electric connection, the consumer is required to sign an agreement with the electricity board on a stamp paper. Though the cost of the stamp paper may not be large, the consumer in rural areas has to spend a lot of time in securing the paper often having to travel considerable distance for it. It should be examined whether an agreement can be executed on an unstamped paper. This may require a legal provision. Alternatively, the State electricity boards should make stamp papers available at the time of signing the agreement.

19.6.10 Consumers are required to give a guarantee of minimum consumption. If that quantum is not utilised during the period, a specified amount is charged. The inability of a power user to consume the minimum prescribed amount may arise out of circumstances beyond his control. For instance, his well may go dry or there be prolonged interruptions and shut-down in the supply of power. We recommend that in such cases the imposition of minimum consumption guarantee should be waived.

19.6.11 When a farmer has secured electric connection for his tubewell or pumpset, he should not be restrained from sharing with or selling water to other farmers.

7 OTHER MATTERS

19.7.1 As in all other developmental activities, public participation in rural electrification is also important. It gives the people a feeling of involvement and, in consequence, secures their whole-hearted cooperation. Much of the work of rural electrification is of a technical nature which can be handled only by trained people. Nevertheless, there are items such as digging pits for erection of poles, transporting material, providing unskilled labour to assist the skilled personnel in which local assistance can be invaluable. For expediting electrification programme in an area, people can be willing to offer voluntary labour, which brings down the cost. An experiment of this nature has been tried in the electrification of certain villages in Andhra Pradesh and the State Electricity Board claims to have effected a saving of about

10 per cent in cost. We recommend that such voluntary support by local people should be encouraged.

19.7.2 With the increase in the tempo of rural electrification and the heavy responsibility devolving on the state electricity boards on this account, the cooperative system of electricity distribution in rural areas can be promoted. This would supplement the efforts of the boards and at the same time encourage direct participation and involvement of the people of the area. At the instance of the Government of India, five rural electric cooperatives have been formed as pilot projects with the assistance of the REC by giving suitable loan and advice. There is one each in Andhra Pradesh, Maharashtra, Gujarat, Karnataka and Uttar Pradesh. On completion of their programme, these will have energised 27,605 pumpsets and made power available to 1,553 small industrial units. In all, 729 villages will have been electrified. We are glad to note that based on the experience gained in the working of these rural electrification cooperatives, the REC is endeavouring to promote several more such cooperatives.

19.7.3 We are glad to note that the REC has a fairly comprehensive programme of research concerning rural electrification. Vast sums will be invested on rural electrification in the years to come. Any research results which lead to economy and efficiency of service would be of great significance. We suggest that financial considerations should not come in the way in taking up of a comprehensive programme of research.

19.7.4 With an extensive network of electric lines in the rural areas and a very large number of consumers, accidents are bound to happen unless people are made aware of the necessary safety precautions and the proper handling of electrical equipments. It would be desirable for the State electricity boards to organise demonstration and training camps to educate the people in the matter.

8 SUMMARY OF RECOMMENDATIONS

19.8.1 The more important recommendations are given below :

1. The tempo of rural electrification should be stepped up so as to make electricity available for pumpsets and rural industries in practically all the villages by 1990.

(Paragraph 19.3.1)

2. The State electricity boards should prepare a well-considered and coordinated programme of rural electrification in consultation with the other development departments at the state, district and block levels.

(Paragraph 19.3.2)

3. Advance planning for the future programme of electrification is essential and the state electricity boards should take early action on the following aspects:

(i) assessment of requirement of power and making arrangements to meet the same;

(ii) assessment of requirement of Extra High Tension (EHT) and High Tension (HT) net works and initiation of appropriate action to meet the same;

(iii) assessment of requirement of materials and arrangements for their indigenous procurement;

(iv) assessment of requirement of personnel and arrangements for their training; and

(v) carrying out of connected research and development work.

(Paragraph 19.3.3)

4. The present difficult power position should not be permitted to hamper agricultural development and the requirements of rural electrification should continue to be accorded a high priority.

(Paragraph 19.3.4)

5. The State Governments should take steps to encourage rural loads by promoting dispersal of industries to rural areas.

(Paragraph 19.3.5)

6. The State electricity boards should take advantage of the funds placed at the disposal of the REC for granting loans, to provide street lights in *harijan basties* as were left out while electrifying the village within the next two years. The charges for electricity consumed by these *basties* should be borne by the State Governments concerned.

(Paragraph 19.3.7)

7. The State Governments should take suitable action to extend electricity to primary health centres for which 50 per cent subsidy is allowed by the Centre, within about two years.

(Paragraph 19.3.8)

8. The electricity boards should give special consideration to extending electricity to fishermen colonies along the sea coast.

(Paragraph 19.3.9)

9. Wherever famine relief funds are used for deepening of existing wells or digging of new wells, funds should also be provided for electrifying them.

(Paragraph 19.3.10)

10. In order to minimise the financial loss on rural electrification schemes, it is important to bring about maximum economy in capital costs through standardisation without sacrificing safety considerations and also to take steps to improve the load factor and thus the revenue through larger use of power.

(Paragraphs 19.4.2 and 19.4.3)

11. The electricity boards should take urgent steps to bring down the losses in the existing systems and ensure that the future distribution systems are designed to give only tolerable line losses.

(Paragraph 19.4.4)

12. The State electricity boards should have the authority to disconnect the power supply to a consumer who is adopting various malpractices. This authority should be exercised only by a responsible officer of the electricity board.

(Paragraph 19.4.6)

13. The Centre/State Governments should subsidise part of the capital cost of the schemes for transmission and subtransmission lines to be installed by State electricity boards in backward areas so as to satisfy the norms prescribed by the REC. Similarly, where villages are far away from each other and the inclusion of the cost of 11-KV lines makes the schemes for electrifying them unremunerative, the REC may consider giving special loans for the 11-KV lines by treating them as transmission lines.

(Paragraph 19.5.4)

14. Credit facilities should be extended to farmers and small scale industrialists, including for the electrification of their homes, for meeting the initial cost and connection charges, etc.

(Paragraph 19.5.5)

15. The state agro-industries corporations should be charged with the responsibility for the supply of quality equipment at reasonable prices.

(Paragraph 19.6.3)

16. Agro-service centres should be set up to provide the services of licenced electrical wiremen/electricians for attending to repair work including rewinding of motors at reasonable rates.

(Paragraphs 19.6.4 and 19.6.5)

17. Pending investigation of a contested bill, the consumer should be charged on the basis of average consumption for the past two months. Fictitious reading of meters which is generally the cause of wrong billing should be considered a serious offence and persons found responsible for it should be suitably punished.

(Paragraph 19.6.6)

18. The system of sending bill collectors to specified places in the villages on specified days should be introduced by the electricity boards, who have not done so, so far.

(Paragraph 19.6.7)

19. The theft of transformers, conductors and other materials and the possession of such stolen articles should be made a cognizable offence under the Electricity Supply Act, as is the case in the Indian Telegraph Act. (Paragraph 19.6.8)

20. The State electricity boards should make stamp paper available at the time of signing the agreement.

(Paragraph 19.6.10)

21. The imposition of minimum consumption guarantee charges should be waived if the circumstances are beyond the control of the consumer.

(Paragraph 19.6.10)

22. When a farmer has secured electric connection on his tubewell or pumpset, he should not be restrained from sharing with or selling water to other farmers.

(Paragraph 19.6.11)

23. For expediting the electrification programme in an area, voluntary labour offered by the people should be fully utilised and encouraged which would also bring down the cost.

(Paragraph 19.7.1)

APPENDIX 19.1

(Paragraph 19.2.3)

Statewise Investment on Rural Electrification by plans

(Rs. crores)

States	First Plan (1951-56)	Second Plan (1956-61)	Third Plan (1961-66)	Three Annual Plans (1966-69)	Fourth Plan (Provisional)
1	2	3	4	5	6
Andhra Pradesh	0.59	8.12	16.43	15.16	64.57
Assam	0.02	0.21	0.43	3.13	6.25
Bihar	0.09	2.17	4.34	14.87	35.22
Gujarat	1.10	4.00	9.18	17.21	36.67
Haryana	..	..	..	12.08	51.82
Himachal Pradesh	..	..	..	..	8.93
Jammu & Kashmir	..	1.36	2.71	1.66	5.80
Karnataka	0.05	4.74	9.66	17.55	1.20
Kerala	..	1.17	2.33	2.50	19.19
Madhya Pradesh	0.59	5.60	11.57	9.95	63.78
Maharashtra	1.20	9.40	19.97	39.46	100.86
Manipur	..	..	..	..	1.20
Meghalaya	..	..	..	..	1.42
Nagaland	..	0.14	0.14	0.07	0.27
Orissa	0.28	1.89	3.78	2.30	29.00
Punjab	0.03	5.20	10.77	11.57	33.39
Rajasthan	0.04	1.95	1.83	8.06	28.74
Tamil Nadu	1.85	17.00	35.66	30.80	121.74
Tripura	..	..	..	..	0.50
Uttar Pradesh	0.94	8.73	17.81	44.12	123.12
West Bengal	1.22	0.30	0.60	2.66	32.95
total States	8.00	72.08	147.21	233.15	809.10
total Union Territories	..	2.92	5.66	3.75	9.63
total All India	8.00	75.00	152.87	236.90	818.73

Notes : 1. The figures upto column 5 have been collected from CWPC.

2. The expenditure shown under column 6 is provisional (as on April 1974) and consists of the following components:—

   (a) Actual expenditure incurred by the States under their annual plan allocations for the years 1969-70, 1970-71, 1971-72, anticipated during 1972-73, and plan allocation in 1973-74.

   (b) Amount disbursed by REC during the years from 1969-70 to 1973-74.

   (c) Expenditure incurred by the States through financial assistance from any other institution upto 1971-72.

3. The figures for 2(a) & (c) above have been collected from the CWPC.

4. The contribution of REC in total expenditure of Rs. 761.02 crores in Fourth Five Year Plan is Rs. 151.82.

APPENDIX 19.2

(Paragraphs 19.2.3 and 19.3.6)

Statewise Number of Villages Electrified[1]

States/Union Territories	Number of Villages*	Beginning of First Plan	End of First Plan	End of Second Plan	End of Third Plan	End of Annual Plans	As on 31-3-1974	Percentage electrified
1	2	3	4	5	6	7	8	9
Andhra Pradesh	27,221	119	517	2,433	4,099	5,585	10,262**	37.7
Assam	21,494	..	..	13	66	331	1,146	5.3
Bihar	67,566	4	300	2,305	3,744	6,350	9,605**	14.2
Gujarat	18,275	37	130	678	1,671	2,869	5,638	30.9
Haryana	6,731	..	99	570	1,179	1,464	6,669**	99.0
Himachal Pradesh	16,916	9	93	670	1,438	2,191	4,500	26.6
Jammu & Kashmir	6,503	..	..	32	383	614	1,380	21.2
Karnataka	26,826	551	1,570	2,920	4,627	7,255	12,644	47.1
Kerala	1,268	159	381	872	1,083	1,137	1,375**	100.0
Madhya Pradesh	70,883	9	47	373	1,133	2,754	10,703**	15.1
Maharashtra	35,778	33	237	764	4,273	9,450	16,933**	47.3
Manipur	1,949	9	12	29	115	153	213	0.9
Meghalaya	4,583	..	..	7	23	48	137**	3.0
Nagaland	960	..	..	7	11	41	136	14.2

APPENDIX 19.3 (*Concld.*)

1	2	3	4	5	6	7
Meghalaya	Nil	Nil	Nil	Nil	Nil	Nil
Nagaland	Nil	Nil	Nil	Nil	Nil	1
Orissa	NA	NA	NA	NA	477	2,759
Punjab	NA	3,095	8,514	25,296	59,112	129,566
Rajasthan	30	47	1,038	6,861	18,362	74,696
Tamil Nadu	14,373	32,440	117,695	256,594	410,119	681,258
Tripura	Nil	Nil	Nil	Nil	2	40
Uttar Pradesh	3,046	5,713	9,881	17,402	75,659	233,640
West Bengal	NA	NA	56	437	1,199	6,535
total States	21,008	55,771	197,541	508,562	1,081,442	2,428,093
total Union Territories	Nil	282	1,353	4,069	7,307	13,509
total All India	21,008	56,053	198,894	512,731	1,088,749	2,441,602

1 CWPC
NA—Not Available.

MGIPRRND—4MofA&I/76—Sec I (D)—12-11-76—5,000.